REPORT

OF

THE COMMITTEE

ON SUPPLYING

WATER,

FOR THE

CITY OF NEW HAVEN.

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T. J. STAFFORD, PRINTER.
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To the Freemen of the City of New Haven.

At an adjourned City meeting held June 1, 1852, resolutions were passed, in the words following:

"*Resolved*, That a Committee of nine, of whom the Mayor shall be one, be appointed by the Chair, to enquire and report upon the most feasible method of supplying the City with water, for the extinguishment of fires and other purposes; and that the Mayor be authorized to draw upon the Treasury for such sum as may be necessary for the employment of Engineers to make the necessary estimates, and to carry the resolution into effect.

Resolved, That the Mayor be requested to call a City meeting, to hear and act upon the Report of the said Committee, at as early a day as may be consistent with a full and thorough investigation of the subject."

The Committee appointed in accordance with the preceding Resolutions were, *A. N. Skinner*, *Henry White*, *Ezra C. Read*, *Charles A. Ingersoll*, *Matthew G. Elliott*, *Henry Hotchkiss*, *Wm. H. Ellis*, *Henry Peck* and *Elias Gilbert*.

The Committee soon after their appointment, entered upon the duties assigned them, and appointed *Alexander C. Twining*, *Esq.*, Engineer to make the necessary surveys, investigations and estimates. As Mr. Twining was obliged to be absent a part of the time, the Committee with Mr. Twining's assent, appointed *Michael Ritner*, *Esq.*, Assistant engineer; who acted under Mr. Twining's directions, till the completion of his Report.

Mr. Twining, as will appear by his Report, herewith submitted, entered into a careful investigation of the various sources of supply around New Haven; and has furnished the Committee with much important and reliable information, in regard to the amount

of water required; the capacity of the streams; the head required; the dimensions, position and structure of conduits, reservoirs, pipes and apparatus; the modes of supply by water power, steam power and otherwise, from several different sources; with careful specifications and estimates of each; the distribution in the City; the comparative advantages of steam and water power;—all of which are of great value, to enable the Committee and the City to come to a proper decision. Most of the surveys were made by Mr. Ritner and a party under his personal supervision, agreeably to Mr. Twining's directions; and may be relied upon for their accuracy and good judgment.

It will be seen by Mr. Twining's Report, that he did not decidedly recommend any one of the various projects, but confined himself to investigations, showing the capabilities, advantages, expenses and important facts of each; leaving it with the Committe to examine the whole ground, and to form their opinions from the information derived from his Report and from other sources. This and the variety of the projects proposed, as well as the great importance of the subject has prolonged the investigations of the Committee, beyond their own wishes and the expectations of the public.

The Report considers most of the various possible sources of supply to the number of twelve or more; but passing by others as less advantageous, gives particular specifications and estimates of the six following, of which a particular description will be found in the Report, and which are estimated by Mr. Twining to cost, delivering the water in Chapel street, exclusive of distribution, as follows:

No. 1. The *Quinnipiac* by open Canal nearly three miles to North Haven, to be pumped thence by water power to the ridge west, and thence by brick conduit four miles to Reservoir North of Whitneyville, thence by double twenty-one inch mains (cast iron pipe) 15,600 feet to the City. $399,870 70.

No. 2. *Quinnipiac*, *Pine River* and *Horton's Brook combined;* by open Canal 7½ miles to a point East of the Northeast slope of East Rock, to be pumped thence by water power to Reservoir

on North slope, thence conducted by double mains by Whitneyville and Hartford turnpike to the City (supposed by Mr. Twining to cost $40,000 less than the above.) $359,870 70.

No. 3. *Mill River by water power;* the stream to be set back by dam at the Clock Factory high enough to overflow the dams at the Paper Mill and Waite's Mill to Churchill's dam; and to be conducted from the Clock Factory on the West side by open Canal 4000 feet long, round the point of Mill Rock and the bay of low land to a point back of the house of Mr. Whitney; thence to be pumped by a fall of thirty-four feet to a Reservoir on Sachem's Hill; thence by double twenty-one inch mains to the City. $233,722 90.

[To this should be added Mr. Whitney's price for water, which would very materially increase the cost.]

No. 4. *To pump by steam power* from below the Gun Factory dam to the Reservoir on Sachem's Hill, thence by double mains to the City as in No. 3. $275,080 00.

No. 5. To convey the water from above Churchill's dam by open Canal three miles long, to West side of Sachem's Hill; to be pumped thence by steam power into Reservoir, thence by double mains to the City as above. $263,487 00.

[As this would take water from the five privileges below, the cost of purchase of these rights would probably add largely to this estimate.]

No. 6. To pump by steam power from West River to Reservoir on Beaver Hills ten feet lower than the Reservior abovementioned, and thence by double mains to the city. Estimate same as No. 4. $275,080 00.

After Mr. Twining's Report was made, the Committee received new propositions from Mr. Eli Whitney, in regard to the water power of Mill River; and from Mr. N. C. Whiting and others in regard to the water power of the Quinnipiac, Pine River and other branches of the Quinnipiac, which promised materially to

diminish the estimated expenses; and which required additional surveys and estimates. In the absence of Mr. Twining, Mr. Ritner was requested to make the requisite investigations, especially in regard to one or two of the routes which had not been before particularly surveyed.

The Committee also caused specimens of the waters from the different streams to be obtained, and experiments to be made of their effect upon lead pipe, soldered to other metal, and placed (in jars containing the different waters) in the dark, as nearly as possible under the same circumstances as if in use for service pipe. These waters were collected and experiments were made by Mr. Twining himself, and afterwards the jars containing the water and lead were put in the possession of the Committee for their inspection, and for further experiments. A more particular account of these experiments will be found in Mr. Twining's memoranda, appended to his Report and in Professor Porter's analysis. Other specimens of lead pipe were afterwards by direction of the Committee placed in the different streams by Mr. Ritner, to ascertain whether the pipe would be differently affected by running water.

The Committee also submitted specimens of the different waters, collected partly by Mr. Twining, and partly by Mr. Ritner, to Professor Porter, at the Analytical Laboratory of Yale College, where they were carefully analyzed, so far as to ascertain the amount of impurities or foreign matter in each. These specimens were numbered, and a record of their origin kept by those who collected them; but the places from which they were taken was unknown to the Professor and his assistants, until after the analysis was made and reported to the Committee.

Specimens of water were likewise taken by direction of the Committee, from six principal wells, in different parts of the city, which in like manner were analyzed by Professor Porter. The results of which analyses are herewith submitted in Prof. Porter's reports, with the addition of the names of the streams, and of the wells from which the waters were taken.

The Committee have also made many enquiries in regard to the modes of introducing water into other cities, with their comparative advantages and disadvantages.

With the results of these various investigations before them, the Committee are satisfied that New Haven possesses great natural facilities for introducing an abundant supply of pure and excellent water, at a moderate expense, compared with the expense of other cities for this purpose. So numerous are the sources and modes of supply, that it has been more difficult to make a selection, than to point out one or more plans, which might be adopted with success. The great object is to fix upon the plan, which will involve the least expense, and at the same time furnish a sure and abundant supply, sufficient not only for our present wants, but for all the future wants of any population which may ever inhabit the city. It is important to ascertain not only what plan will involve the least expense in the beginning for a small quantity, but what plan is *capable of enlargement* for a great quantity, with the *least additional* expense; which shall answer not a temporary but a permanent purpose, and which shall cost the City the least not merely in the outset, but shall cost the least, and confer the greatest benefits, in the end.

The plan, No. 1, of bringing the water of the Quinnipiac, as described in Mr. Twining's Report, by open Canal from the Quinnipiac Factory, nearly three miles, to the vicinity of North Haven, and pumping it thence by water power to a Reservoir on the ridge west, and conducting it thence along the ridge by conduit four miles to a Distributing Reservoir on the high ground north of Whitneyville, received considerable favor from the Committee on account of the large and constant supply of water it would afford, the natural adaptation of the ridge for the purpose, and the supposed economy of the plan. But Mr. Twining's estimate so much exceeded the expectations of the Committee, that they turned their attention to other projects. The great distance of the Distributing Reservoir from the City, (it being 15,600 feet, nearly three miles, from Chapel street,) caused a great item of the expense. The double twenty-one inch distributing mains alone were estimated at $156,000.

In all of Mr. Twining's estimates, he proposes double rising, and double distributing mains, which, though desirable, do not appear to the Committee necessary; at least for the present, and add very much to the expense. The Committee have in their

estimates contemplated only one main pipe, which is the usual mode, (unless two are necessary for quantity,) and which is known to be ample, with the diameter and head proposed, to deliver a greater quantity of water than will be required for many years to come. Another main can be added when the increased consumption, and increased revenues from the water shall justify it.

As Mr. Twining's estimates exceeded public expectation, the Committee have endeavored to reduce them, by dispensing with double mains; by bringing the Reservoirs nearer the City; by substituting brick conduits, or open canal, for iron pipes, where practicable; and by restricting the plan of distribution, in regard to the diameter and length of the pipes; with the hope that they might bring the expense within the expectations of the citizens, without material detriment, and that the works might be extended, as the wants of the City shall require, and as the income shall increase, so as not to increase the public burden. The Committee see no reason why the expenses should ever increase beyond the lowest estimates of Mr. Twining.

Soon after the Report of Mr. Twining was made to the Committee, they received a proposition to convey the combined waters of the Quinnipiac, Pine River, Horton's Brook and other smaller streams, by open Canal 8½ miles long, to a point near the S. E. spur of East Rock, where there is a convenient locality for a Reservoir, and where there would be a water power of twenty feet fall. The use of this water and power, to pump water to the extent of the wants of the City, was offered for the consideration of $100,000. "Satisfactory security for the performance of the contract to be given;" the contractors reserving only the surplus power to themselves, after the wants of the City should be supplied. The distance of this proposed Reservoir from the corner of State and Elm streets is 9500 feet; and the spot has natural advantages for its cheap and durable construction, for a head of 130 to 140 feet above mean tide.

A project similar to this (above named as No. 2) is mentioned in Mr. Twining's Report, as less expensive than the one before noticed, but, says the Report—"At the time of entering upon this enquiry an accurate survey could not be made in season"—"but by aid of Mr. Ritner's minute acquaintance with the region,

I was able to make an approximate estimate, which developed the fact that between thirty and forty thousand dollars might be saved by changing the plan."

Mr. Twining's plan differs from the one proposed by the contractors above, only by terminating the open canal, and locating the water power about 6000 feet farther North, and placing the Reservoir on the N. E. slope of East Rock nearly opposite the Gun Factory, instead of the S. E. spur as above mentioned; and conducting the water to the City by Whitney Avenue instead of Hancock Avenue, or State street.

The contractors afterwards varied their proposition so as to locate the water power, if preferred, agreeably to Mr. Twining's recommendation, 6000 feet North of the spot first proposed—for the sum of $86,000.

These propositions were so much more favorable in point of expense, and promised so copious a supply of water, that the Committee gave them their serious attention; and directed Mr. Ritner to make the necessary surveys and estimates to ascertain whether such a contract could be safely made. His estimates, as in his Report herewith submitted, bring the combined waters of the Quinnipiac and its branches above mentioned, to the S. E. point of East Rock as above for $93,866. And to the site mentioned near the N. E. slope of East Rock for $86,000.

Mr. Whitney also made a more favorable proposition than he had before made, viz.: to convey the exclusive right to the whole water power of Mill River as far as needful or available to supply the City with water; including the power created by the dams at the Armory, Clock Factory, Upper Works (formerly Paper Mill) and Waite's Mill, and all land owned by him for flowage; also the site on which the Armory filing shop stands, for water wheels, pumps, &c.; land for Reservoirs of most ample dimensions, and right of way and flowage over all lands owned by him; also right of erecting tide gates granted to him by the Legislature, and right of taking stone from his rock ledge for the construction of the water works; for a sum, which together with the cost of dam, canal, bridge, &c., to be done by the City, will amount to $76,109 20. He reserving the surplus water only for

his use, and placing no restriction on the City in its use of the entire water when required for its supply.

These new propositions presented to the Committee three modes, apparently less expensive than any of those before estimated, though similar to some of them with modifications, but sufficient for the present wants of the City, and capable of enlargement to any desirable extent, viz:

First.—To build a dam at the Clock Factory and set back Mill River so as to overflow the dams at the Paper Mill, and Waite's Mill back to Churchill's dam, as proposed by Mr. Twining;—then conduct the stream by open Canal on the East side of Mill River to the Gun Factory, as proposed by Mr. Whitney; and thence by a fall of thirty-four feet to pump the water by water power to a Receiving Reservoir on Sachem's Hill at a point between Ball Spring and the Gun Factory, thence to conduct the water by brick conduit, to a smaller Distributing Reservoir on Sachem's Hill North of the mansion of Mrs. Hillhouse, and thence by a twenty inch main to the corner of Temple and Elm streets to be distributed through the City.

Second.—To conduct the united streams of the Quinnipiac, Pine River, Horton's Brook and other smaller brooks, by open Canal to a point easterly of the North side of East Rock, as proposed by Mr. Twining;—to pump thence by water power with a fall of twenty feet to a Receiving Chamber on the North slope of East Rock, to conduct thence by a brick conduit to a point over and East of the Gun Factory, thence by a twenty inch main across Mill River valley to the Reservoir, Conduit, Distributing Reservoir, before described on Sachem's Hill, thence as before by twenty inch main, to corner of Elm and Temple streets for distribution.

Third.—To conduct the united streams of the Quinnipiac, Pine River, Horton's Brook, &c., by open Canal to a point 6000 feet southerly of the last mentioned water power, near Cedar Hill, to pump thence by water power with a fall of twenty feet, by a twenty inch main to a Reservoir on the S. E. spur of

East Rock, to conduct thence by a twenty inch main along the Middletown turnpike to the corner of Elm and State streets for distribution.

The Committee on carefully examining these routes, together with Mr. Twining's and Mr. Ritner's surveys and estimates, and such other information as they could obtain, came to the conclusion, by careful estimates of their own, assisted by Mr. Ritner, that the expense of these three modes would be nearly as follows:

1. *Mill River by Water Power.*

Cost of water power, water, land for reservoirs, right of way, flowage, bridge, dam, guard gates, &c. chiefly from Mr. Twining's estimates,* .	$69,609 20
Mr. Ritner's estimate for Canal, &c. . . .	6,500 00
	$76,109 20
20 inch Rising Mains $\frac{3}{4}$ inch thick, 2,200 feet, at $5 per foot, ...	11,000 00
Brick conduit, oval, 3 feet by 4 feet, 8 inches thick, 5,900 feet, at $2 50 per foot, ...	14,750 00
Mr. Twining's estimate for reservoir, . . .	32,500 00
Do. for wheel house, wheels, pumps, &c., . .	18,800 00
20 inch distributing main, to corner of Temple and Elm streets, 4,225 feet, at $5 per foot, . .	21,125 00
Mr. Ritner's estimate for crossing Mill River, .	3,000 00
Distributing reservoir, land damage, engineering, contingencies, &c.,*	12,715 80
	$190,000 00

* The particular items of all the above and following estimates, were examined by the Committee, but for prudential reasons, omitted here as their publication might affect contracts.

2. *Quinnipiac by Whitneyville.*

Water power and water as proposed, ...	$86,000
Mr. Twining's estimate for wheel house, wheels, pumps, &c.	18,800
20 inch Rising Main, 800 feet, at $5 per foot, .	4,000
Brick conduit 3 by 4 feet, 8 inch thick, to a point over Gun Factory, 2000 feet, at $2 50 per foot, . .	5,000
Crossing Mill River, ...	3,000
20 inch Rising Main, 2,400 feet, at $5 per foot, . .	12,000
Reservoirs as before, ...	32,500
Conduit as before, 5,900 feet, at $2 50 per foot, .	14,750
20 inch Main to corner of Temple and Elm streets, 4,225 feet, at $5 per foot, ...	21,125
	$197,175
Reservoirs, damages, right of way, engineering, contingencies, &c.	15,825
	$213,000

3. *Quinnipiac by Cedar Hill.*

Water power and water as proposed, ...	$100,000
Mr. Twining's estimate for wheel house, wheels, pumps, &c., ...	18,800
20 inch Rising Main, 900 feet, at $5 per foot, .	4,500
Reservoir, 1½ acres, estimated by Mr. Ritner, . .	13,000
Main to corner of Elm and State sts., 9500 feet, $5 per ft.,	47,500
Mr. Ritner's estimate for crossing Mill River by stone arch and raising highway 15 feet, ...	6,850
	190,650
Engineering, damages, contingencies, &c., . . .	11,350
	$202,000

Of these estimates it may be said, there has been care to make them high enough, to err, if at all, on the safe side. Mr. Twining estimated the twenty inch main at $4 per running foot, laid. The Committee called it $5, which after very careful examination they believe will cover every thing. Probably Mr. Twining's

estimate was high enough, but they allow for the possible advance of the price of iron and other contingencies. They take the conduit at his estimate, $2½ per running foot, the price in New York, but believe it can be made in New Haven for $2. The principal saving, is by substituting *one* rising and *one* distributing main instead of *two;* and brick conduits for iron mains when practicable; and by diminishing the length of the iron mains by bringing the distributing Reservoir nearer the City.

To these estimates must be added the cost of distribution, which, as the different plans terminate on Elm street, must be nearly the same for each.

Mr. Twining's plan for distribution, is on a larger scale, and more expensive than the City will be likely to want at present. It contemplates nearly thirty miles of pipe, the smallest size of which is six inches diameter, the whole costing over $200,000. Mr. Battin in a plan submitted to the Committee, proposed nine miles,* the smallest, of four inch diameter, costing probably about $60,000. Mr Ball in his plan proposed thirty-five miles, running the length of every street, a large portion of which is five, four, three, and two inches diameter, costing about $104,184.

In Philadelphia there are 113 miles of pipe, of which about one-fourth or 115,878 feet, nearly twenty-two miles, is three inch pipe. In Boston there are 103½ miles the least (about one-sixth of the whole) is four inch pipe. The President of the Croton Department, New York, recommends four inch pipe as the smallest.

From fifteen to eighteen miles of water pipe, the smallest of four inch diameter, can be laid in New Haven for about $100,000, which will be perhaps a fair calculation for the beginning—(there are now about 10⅗ miles of gas pipe laid in the City). The pipe may be afterwards extended as the wants of the City require, and as the income shall increase to meet the interest of the additional cost.

Taking therefore the estimates of the Committee on the three plans described, viz., $190,000, $202,000 and $213,000, and adding to this the $100,000 for fifteen to eighteen miles of pipe, it appears that the water works for the City, may be commenced on a scale adapted to our present wants for about $300,000.

* Ten miles, including sixteen inch main.

When the time arrives that the City shall require four or five millions of gallons, about triple its present wants, another twenty inch main may be added if necessary to each of the foregoing plans, thus completing Mr. Twining's plan of introducing the water by double rising and double distributing mains, for such sums as shall make the three plans cost severally, No. 1, $222,125, No. 2, $250,225, No. 3, $254,000.

In the mean time, there will be gradual additions for extended distribution, costing in the end from $50,000 to $100,000 more, according to its extent and the increase of the City. Making the whole complete with double mains, thirty or more miles of distribution for $400,000 or $450,000. But the whole of this additional expense will not be necessary till the City shall be greatly increased, at least to double its present size, when it will have more than double its present means—and when the increase of water rates will probably be increased beyond the annual interest of the whole cost, and its annual expenditures on the water works, leaving a surplus as a sinking fund, and ultimately a clear revenue to the City.

That this result is not chimerical will appear from the following statement taken from the annual report of the Fairmount water works for 1852.

Total cost of water works from July 1, 1822, with yearly expenses added to Dec. 1, 1851, .	$1,707,550 00
Interest on do. at 6 per cent.	102,453 00
Amount of Revenue for 1852, . . .	150,038 67
Excess of Revenue over Interest, . . .	47,585 67
Annual Expenses for 1852, ...	24,583 63
Excess of Revenue over Interest and Annual Expenses, ...	23,002 04
Appropriated to Sinking Fund, . . .	35,320 00

The income thus paying the interest of the whole cost of the works, including the former annual expenses, the expenses for this year, and leaving a handsome surplus for the Sinking Fund.

When we look at this result, and also consider that it is a well known fact that water companies make great profits, we may

safely anticipate that in the course of not many years, the income from the water rates would be such in New Haven that it would be able to extend its works without any serious burden: provided this generation so begin the works that they will be economical in the end. We think such a beginning may be made for about $300,000 which need never increase above $400,000 to $450,000 even a quarter of a century hence, when the City shall have double or triple its present population.

In comparing the three plans above described, it appears they do not greatly differ *in expense;* the difference of $10,000 to $20,000 being in favor of Mill River. Neither of them differ far from $200,000.

In regard to *quality* of water they are nearly equal, the difference being very slightly in favor of Mill River, if Pine River be united with the Quinnipiac. Both Mill River and the Quinnipiac are very pure waters, purer than the Croton or the Schuylkill or any waters known as being introduced into cities, except the Cochituate, and much purer than any wells in the City which have been examined. Pine River is nearly equal, being about as pure as the Schuylkill and much purer than the Croton or any of our wells.

It will be found on referring to Professor Porter's Report, that the amount of impurities or foreign matter in the different waters is as follows: the figures denoting so many parts in a million, or so many millionths of organic and inorganic matter in each.

	Cochituate.	Mill River.	Quinnipiac.	Schuylkill.	Pine River.	West River.	Croton.
Organic,	10	15	10	20	18	35	72
Inorganic,	21	58	65	74	77	68	115
Total,	31	73	75	94	95	103	187

The foreign matter in the different wells in the City was found to be as follows:

	Millionths.
From the pump corner of State and Olive streets,	166
" " S. E. corner of Public Square, . .	270
" Chapel street near Park street, . . .	270
" Baths, Orange street, ...	394
" corner of State, George and Fleet streets, .	709

It thus appears that any of the streams about New Haven have a desirable and remarkable degee of purity, the Mill River and Quinnipiac being the best, and the West River into which the Beaver Ponds empty, the least pure. That all these streams are much purer than the best wells in the city; and that of the wells examined, those in the Northern parts of the city are the purest, the amount of impurity increasing the nearer they approach the harbor.

In regard to the effect of the waters upon leaden pipes. In the experiments made by placing pieces of the pipe in jars containing the water, none of them appeared to be much affected except the one placed in the water from Beaver Pond, although they had remained standing in a dark closet several weeks. Those placed in the waters from the Mill River and the Quinnipiac were least affected, or not affected at all, except a slight cloudy deposit where the pipes came in contact. But neither the waters or the cloudy deposit were found by analysis to contain any lead.*

From the very thorough and scientific investigation of the Boston Committee, it seems satisfactorily settled that waters from lakes or running streams do not operate on lead pipe, so as to produce injurious effects upon health. The only perceptible effect is to produce a slight coat after a use of a few days which coat becomes insoluble and ever after protects the pipe from corrosion.

In regard to *quantity of water*, the choice is decidedly in favor of the Quinnipiac.

It will be seen by Mr. Twining's Report that the minimum quantity flowing in the driest time in Mill River in twenty-four hours, is 11⅝ millions of gallons, which with its fall of thirty-four feet, would raise 1,900,000 gallons per day to an elevation 132½ feet above mean tide; or over 2,000,000, as high as we shall probably require, say from 120 to 125 feet. "But the stream in ordinary seasons would exceed this, and by aid of Reservoirs might be reliable for a greater amount, say 2,500,000 gallons per day," by water power in the driest times.

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* A subsequent examination some weeks after discovered slight traces of lead in the sediment at the bottom of some of the jars but not enough to affect the result. The waters are in this respect excellent.

The Quinnipiac, according to Mr. Twining, affords, at its minimum flow in the driest time, $32\frac{1}{3}$ millions of gallons in twenty-four hours, which with a fall of $19\frac{1}{2}$ feet, will raise over 2,900,000 to an elevation of $140\frac{3}{4}$ feet above tide, or over 3,250,000 to the height of 125 feet. "In ordinary seasons," continues Mr. Twining, "the river at its minimum flow would be competent to throw 3,600,000, and by the establishment of Reservoirs, might be competent to so much more in *every* season." If we add to this the increased quantity, which would be raised by the same power, by diminishing the head from 140 to 125 feet, and the quantity which would arise by the addition of Pine River, Horton's Brook and other brooks and springs on the East side, there can be but little doubt that the Quinnipiac and its tributaries may be relied upon to raise in the driest seasons 5,000,000 gallons per day, and in ordinary seasons much more.

The ordinary computation for a supply of water is thirty to forty gallons to each individual per day. In most foreign cities it is less than this. In London twenty-three gallons; in Philadelphia thirty-five, often running above; in Boston it was found in 1849 to be actually sixty-one; in 1850, sixty-three; in 1851, sixty-six gallons; in New York about sixty, but sometines rising to ninety gallons a day to each individual.

In New Haven we should ordinarily expend less, but in the driest time when the water will be the scarcest, we should probably expend as much water to each individual, as Boston or New York, on account of the far greater number and extent of our gardens and the dry nature of our soil. This use of water for gardens will be a new element in estimating for New Haven, which probably has more surface under culture for gardens and ornamental grounds than any of the larger cities.

Assuming then sixty gallons for each inhabitant, (the average for New York and Boston,) our population of 25,000 will require a daily supply of 1,500,000 gallons at the outset. Less than this will probably be ordinarily used, yet considering the demand for water there will be in the driest season, it will not be safe to arrange for less.

At 60 gallons* per day, for each inhabitant, the following table shows our probable wants for the future:

1,500,000	gallons will	supply the	present population	of	25,000
2,000,000	"	"	"	"	33,333
2,500,000	"	"	"	"	41,666
3,000,000	"	"	"	"	50,000
4,000,000	"	"	"	"	66,666
5,000,000	"	"	"	"	83,333
6,000,000	"	"	"	"	100,000

From this calculation it appears that Mill River, by its water power alone, will supply the City in the driest time, for 30,000 to 40,000 inhabitants. But when the population increases beyond that, it will probably be necessary to add steam power, for one or two months in the driest seasons. With this addition, Mill River would supply the City for any probable population, as the ordinary flow of the river is double or triple its minimum.

The Quinnipiac and its tributaries, by its water power alone, will supply the City for a population of 75,000 or 100,000, even in the driest time, and will supply double or triple that quantity in its ordinary flow. The capabilities of both streams may be much increased by retaining Reservoirs.

Mill River has the advantage that it is near, accessible, less expensive, and less liable to risks of expenses not anticipated: but the disadvantage that at its minimum flow, it will require the aid of steam power in the dry season, after the City shall increase beyond 40,000 inhabitants.

The Quinnipiac has the advantage that it will supply the City to any probable increase, without the aid of steam, and its additional expense; that it will bring a new water power, with its advantages, near to the City; but the disadvantage of a little

* Or at Mr. Twining's estimate of 40 gallons to each, we have the following table:

1,000,000	gallons will	supply the	present population	of	25,000
2,000,000	"	"	"	"	50,000
2,500,000	"	"	"	"	62,500
3,000,000	"	"	"	"	75,000
4,000,000	"	"	"	"	100,000
5,000,000	"	"	"	"	125,000
6,000,000	"	"	"	"	150,000

more cost at the outset, and more risk as to the future costs, repairs, &c. This risk may, perhaps, be counterbalanced by so framing the contract that the whole property should be pledged to the City as security for the faithful construction of the Canal, and keeping the same in repair. The surplus water power is supposed by the contractors to be a valuable property; if so, its revenue might be sufficient to keep the works in repair.

Another method has been considered by the Committee, viz: that of pumping the required water by steam power instead of water power.

Mr. Twining suggests three methods of raising the water by steam. 1. From below the dam at Whitneyville. 2. From West River, to be pumped to a Reservoir on Beaver Hills. 3. From a Canal three miles long, from above Churchill's dam.

The advantage of raising the water by steam, is,

1st. That the first cost of the water, in the first two methods above mentioned, will be little or nothing, as it is proposed to take it from below any water power now in use, or of any value.

2d. The whole flow of the stream or the whole quantity of water may be conducted to the City, as none will be required for power to work the pumps, this power being supplied by steam. And consequently Mill River, or even West River would furnish enough for all time. The minimum flow of Mill River is over 11,000,000 gallons per day, and of West River more than half that quantity, so that more than 10,000,000 might be pumped from Mill River, enough for 200,000 inhabitants, and more than 5,000,000 from West River, enough for 100,000.

But the great objection to steam power, is the great annual expense of fuel, repairs, &c., which expense will constantly increase *in proportion to the increase of the quantity of water required.*

According to Mr. Twining's estimate, the first cost of steam works, including the capital of which the annual expense is the interest, to raise 1,000,000 gallons per day, would not differ materially from the first cost of water works to perform the same duty. By referring to his Report, it appears that the steam engine, pumps, and other apparatus to raise 1,000,000, with the capacity by additional expense, to raise 2,400,000, will cost, including the capital of which the annual expense is the interest, $134,330.

By the same estimate, the water works to perform the same duty will cost, - - - -	$74,172 00
To which add cost of water power, land, flowage, dam, bridge, &c., as above, - - -	76,109 20
By water power, for 1,000,000 gallons, - -	$150,281 20
By steam power for do. do. - -	134,330 00
So that on the first million the difference is in favor of steam, - - - - - -	$15,951 20

But for the second million by steam, according to his estimate, we must add a capital of $60,000, and so on, $60,000 for each additional million. But by water power only $13,000 for two, and only $25,000 for three millions. In the language of the Report:

"It should be observed, in the comparison of the foregoing methods and amounts, that they present a fair comparative view for the present time only, when 1,000,000 gallons will meet the ordinary daily demand. If two millions were requisite instead of one, there would appear against the method by steam, when compared with water power, a balance of about $60,000 more than at present, and the like amount for each additional million."

Applying this principle together with the following remarks of his Report,—adding to the capital $60,000 for every additional million by steam, and the comparatively small sum of $12,500 for every additional million by water power, we find that as we require two, three, four, five, or more millions, the comparison in point of economy is immensely in favor of water power over steam.

Thus the additional expense for each additional million, will be as follows:

	By Steam.	By Water Power.
For 2,000,000	$60,000	$13,000
" 3,000,000	120,000	25,000
" 4,000,000	180,000	37,500
" 5,000,000	240,000	50,000
" 6,000,000	320,000	62,500

These calculations are based on the use of the Cornish engines, (which are supposed to be much the most economical of

any in use,) and are corroborated by striking facts, and by the opinion of every person of science or experience.

In the Annual Report of the Water Committee of Philadelphia for 1852, (page 8,) we find the following remarks on the importance of continuing water power instead of steam:

"In order that the importance of continuing water power as long as possible may be appreciated, the result of a comparison of the cost of steam and water power is here given:

"The total expense of running the eight wheels and pumps at Fairmount in 1850, was as follows:

	Per annum.		Per day.
"For wages of workmen, tallow, oil, packing yarn, and fuel for heating the mill house, was	$2,594 91	or	$7 10 8
For repairs to the wheels and pumps during the year,	216 27	or	0 59 2
Total cost per year,	$2,811 18		$7 70 0

"For which sum, 4,785,338 ale gallons per day were pumped by the eight wheels and pumps, equal to a cost of about $1 61 per million gallons raised per day.

"From information kindly furnished by the Register of the Spring Garden and Northern Liberties Water Works, the cost of pumping by steam power at those works in 1850, was shown to be as follows:

	Per annum.		Per day.
"For coal, wages, tallow, oil, yarn, &c.,	$16,644 00	or	$45 60
For repairs to engines, and pumps,	5,127 46	or	15 06
	$21,771 46		$60 66

For this sum an average of 3,231,254 gallons per day were pumped by three engines and pumps, costing about $18 77 per million gallons per day."

Thus it appears by official documents that in the same city, the cost of pumping by water, in 1850, was to the cost of pumping by steam, as $1 61 is to $18 77, or nearly as 1 to 11½.

And yet men can be found who will say they prefer steam to water power. That may be true when the object is a temporary one, where a small quantity is to be raised for a few years, and where no regard is had to a permanent and increasing supply.

Every person of experience and science who has been consulted, has given an opinion decidedly in favor of water power over steam, and in favor of a natural head over either, where practicable. This will be found almost the universal opinion in the Reports of the Engineers who have acted for the different cities.

The fact that steam power requires constant expense, that every additional quantity of water raised, requires a corresponding additional quantity of coal: while water power once purchased requires no feeding, and performs to the full extent of its power with little or no additional expense, gives a decided preference to water power over steam especially where great quantities of water are required, and when great and permanent works are to be constructed.

The only remaining mode of supply to be considered is that of introducing water from some source which has sufficient natural head to dispense with both water and steam power. Whenever an abundance of pure water can be obtained with such a natural head, this mode is to be preferred to all others, provided its distance, position, and the intervening country admit, without too great difficulty and expense. This is the mode in which the Croton supplies New York; the Cochituate, Boston; the Patroon's Creek, Albany; and many other rivers, springs or lakes supply other cities; and is the mode that has been preferred, when practicable, in modern, as well as ancient times.

The only plan of this kind which has been seriously considered is to bring the water from Pine River, miscalled Muddy Brook, which rises among the hills of Meriden, Wallingford, and Northford, and empties into the Quinnipiac on the East near Sackett's Point, nearly two miles South of North Haven. This is a fine rapid stream, with many branches from springs and brooks, with an extensive water-shed, and is said to be less affected with drought than many streams. About ten miles from New Haven, at Tyler's Dam, it has a head of 150 feet above tide, and a very convenient position to build a dam and thus between two ranges of hills to construct a very capacious Reservoir, without much expense.

Mr. Twining's estimate of the minimum flow of this stream was less than had been anticipated, and less than the estimates of

several others, some of them engineers or men of practical experience. He says that his survey was rapid, and that the results of his guages "were made irregular by the unequal discharges from the dams," and that "all that could be determined in a general way proved to be" a flow of "2,600,000 gallons per day." Some who have examined this stream, believe that its natural flow aided by retaining Reservoirs for which the country is well adapted, would furnish an ample supply to New Haven in all time to come. But the great objection to this stream is the distance of its appropriate place for a Reservoir of suitable head, and the character of the intervening country. If there were a continuous ridge of high ground, like the ridge between the Quinnipiac and Mill River valleys from North Haven to Whitneyville, this might be worthy of the first consideration. But the ground descends rapidly in a direct line from the dam, and the water would have to be conducted almost entirely by iron pipes; or by a conduit a part of the way on a circuitous route, and by a considerable length of iron pipe to cross the low grounds of the Quinnipiac valley, the expense of which has been thought a serious objection; especially as we have two other sources of supply which have appeared more advantageous.

A proposition was early made by J. Ball & Co., to conduct this stream to the City, and to distribute it with very ample lengths of pipe, about thirty-five miles, but of smaller diameters than have been recommended by others, for the sum of $233,424

Exclusive of water rights which would cost about	25,000
	$258,424

The diameters estimated by him were 16, 12, 8, 6, 5, 4, 3 and 2 inches, a large portion of the whole being below 5 inches diameter; the main conducting pipe ten miles long and 16 inch diameter. This pipe is of a new construction, made of sheet iron rivetted like steam boilers, and lined outside and in with a thick coat of cement. The pipe appears well, is said to be perfectly secure from rust, and free from all impurities or obstructions to affect the water; and for these reasons requires less diameter. But as it has not been fully proved of such large diameters as would be necessary for the Mains, the Committee have not

felt justified from present information in recommending it to the City. It may be worthy of further consideration.

The next, and a very important question is, whether the water works should be the property of the City or the property of a private Company.

Mr. Joseph Battin made a proposition to the Committee to furnish the City with water: he agreeing to take all the stock of the Company except $50,000 which he wished to be taken by the citizens; or he would take less if preferred.

His plan was to pump the water from Mill River below the dam at the Gun Factory by steam power;—to erect guard gates to keep out the salt water;—to raise the water through a cast iron twenty inch main 'to a Receiving Reservoir on the hill sufficient to distribute it with a head of 110 feet;'—to convey thence by brick aqueduct along the margin of the hill to a distributing Reservoir, in the rear of the dwelling of Mrs. Hillhouse.

The proposed Receiving and Distributing Reservoirs, containing together from four to six acres, to be connected by a brick conduit; the water to be conveyed to the City in a sixteen-inch main going through the City 1½ miles, to be distributed by

1½	miles	12 inch pipe.
1	mile	10 " "
2	miles	6 " "
4	"	4 " "

In all ten miles, including sixteen-inch main 1½ miles.

Mr. Battin at first thought the cost of the plan would be $250,000, afterwards $300,000; but in his last communication was "not fully prepared to state the amount for which he would do the work and furnish the materials," but should the City give it out by contract, "would desire to propose for it, to furnish all or any part of the capital."

If he took the Stock of the Company, he proposed to furnish the City with water for extinguishing fires for $40 per annum for each hydrant without stint. "The price for Fountains to be determined by conference between the parties."

There have been some other propositions of a similar character, but too vague and indefinite to require notice.

(*Note to page* 24.)

THE following letter, in addition to Mr. Battin's former proposals, was received after the Report was printed :

NEWARK, Feb. 11, '53.

MY DEAR SIR,

Some weeks since I sent to his Hon. Mayor Skinner, a statement of the plan I suggested for supplying your city with water. (in answer to enquiries by him.)

In addition to that I wish you would be so kind as to present the following :

I will contract to do the whole of the work as proposed in that communication, (adding two miles of Pipe,) for the sum of $350,000, and furnish all or any part of the Capital to do the work. The city shall have the right to take the works any time within ten years, by paying to the company 15 per cent advance on the cost, and securing to the company an interest of at least 8 per cent up to the time of so taking it. The cost of water shall not exceed (to private consumers) the average of the three lowest rates paid by cities of the United States.

Should they think fit to give us the work, we can give satisfactory security that it shall be faithfully performed, and in the best manner.

Very respectfully yours, &c.,

JOSEPH BATTIN.

HENRY PECK, Esq., New Haven, Conn.

The principal object of introducing water into the City, is in the language of the Resolution appointing the Committee, that "of supplying the City with water for the extinguishment of fires." The great object is to provide for the Fire Department, a copious supply of water, every where accessible where it is most needed to protect the City from conflagration. So important is this object, that without it, all other objects, however desirable, would hardly be sufficient to enlist the whole City in favor of the enterprize.

The Engines and Apparatus of the Fire Department, are owned by the City: and it seems highly important that the Water Department, which will supply the chief element of its efficiency, should be owned by the City also: that there should be no stint or restriction on the free use of the water for the public service: that the Fire Department may use the water by hose, by hydrants, by engines, in any manner and in any necessary quantities, to extinguish fires; to prove the machines; to drill the companies by practice; without being responsible to any private interest, but only to the City itself; which owns the apparatus—which can have no interest but the public good; and which for its own safety and prosperity, wants an efficient Fire Department, and an abundant, unrestricted supply of water.

It is obvious that where the water works are owned by a private company, the profits must be its sole object, and these profits, especially if steam power is used, must depend upon the smallness of the quantity of water used as well as upon the amount of the price paid for it:—that the interest of the company and the interest of the City must be in frequent collision:—that the Fire Department will often be in controversy with the water company;—and that this dependence of the City upon a private interest, will materially diminish the benefits of both the Water and Fire Departments, and cause the City much trouble and detriment.

The interests of the citizens and the prosperity of the City require that the water should be supplied in liberal quantities and at the lowest rates.

The object of a private company must be to make money. The smaller its supplies, and the higher its rates,—the less its

expenditures for substantial and durable works, and the less liberal its policy to a certain extent;—the greater its profits. No company can be formed, or can exist, unless on a basis of making such profits, as capitalists are now finding for their investments, which profits are known to be great. It is obvious that such a company cannot and will not furnish as liberal supplies at as low a rate as the City. For the City does not want to make great profits. It only wants an income to pay the interest of its investment, with such a moderate surplus, as will gradually make a Sinking Fund to pay its debt. The City can afford to receive even less than its interest. It formerly paid $3000 per annum for the limited supply of the old canal, which was accessible but to a small portion of the City. It can afford to pay twice that sum, for an abundant supply throughout the City, not to be pumped from the old Canal or sunken Cisterns, but to flow by its own force, not only to fill the Engines without labor, but in many places to be thrown in resistless quantities directly upon the fire itself; thus spontaneously doing the work of many Engines.

Besides, if a company own the works, the City will be obliged to pay this or a greater annual sum to the company, depending on the number of Hydrants and the quantity of water used. And this sum would be gradually increasing, as the City by its increase should require more water and more Hydrants. Thus the City would be subjecting itself to an annual increasing tribute to swell the profits of a private corporation, without any share in the profits, without any prospect of ultimate redemption except at great costs, without control, and without the advantage of using its own property in its own way for its own interest.

After the works are fairly established it is not probable that the excess of the interest over the income will long remain greater than the annual sum the City would be obliged to pay to a company. And we may safely infer from the experience of other cities, that the income will gradually increase till it equals or exceeds the interest. Thus if the City own the works it will annually pay less and less, till the works become a source of revenue instead of expense; whereas its payment to a company will be greater and greater without any acquisition of property.

The Fairmount works, as before mentioned, now produce an income sufficient to pay the interest of the whole cost, the annual expense, and a handsome surplus to the Sinking Fund.

The income of the Cochituate works the first year after they were in full operation was $97,943, about one-third of the interest;—the second year 160,946, over one-half of the interest;—and the third year $190,000, over two-thirds of the interest; and the income is expected to increase in a similer ratio, till in a few years it will equal or exceed the interest.

The Croton works, notwithstanding their immense expense, in 1852, ten years from their establishment, received an income of $520,000, equal to about five-sevenths of the interest, which is $702,000.

Both the Croton and Cochituate are built without regard to expense, and cost far more in comparison than ours will. But if our works should pay in no greater proportion than these, the city would pay less for excess of interest over income even the first five years, than it would pay a company; and after that, less and less, till free from its annual tax for interest, and finally free from its debt: and would then possess a great and valuable property, imposing no burden, and contributing immensely to its prosperity.

It is said the City may now make a loan at 5 per cent. interest; the interest on $300,000 is $15,000. Suppose one-third of this paid by the income the first year as in Boston, the City would have to provide for $10,000, two-thirds of the interest, the first year—for $7,500, one-half the interest, the second year, about the sum a company would require,—for $5,000, one-third of the interest the third year,—less than a company would require; and so on, in five or six years paying on an average less for interest than it would have to pay a company. After that its condition would be far more favorable.

Another view of the subject is presented by the following statement prepared by one of the Committee skilled in finance.

It is admitted without doubt that the bonds of the City payable in twenty to forty years, will now sell for premiums from 12½ to 15 per cent., at which rates, on $300,000, they would produce $37,500 at 12½ per cent.;—$40,000 at 13⅓;—$45,000 at 15 per cent. Which sums being put at compound interest as a sinking Fund will cancel the whole debt, in periods between

thirty-two and thirty-six years, as will be seen by the following calculations.

$12\frac{1}{2}$	per cent.	Premium	on		$300,000 is	$37,500
$13\frac{1}{3}$	"	"	"	"	$300,000 is	40,000
15	"	"	"	"	$300,000 is	45,000

Amount.	per cent.	How interest is computed.	Years.	Months.	Days.	Amount.	Per cent.	How interest is computed.	Years.	Months.	Days.	Amount.
37,500	6	Compound interest annually in ...	11	10	22	75,000	6	Payable semi-annually,....	11	8	21	75,000
37,500	"	" " "	25			160,893	"	" " "	25			164,000
37,500	"	" " "	35	8	6	300,000	"	" " "	35	3	21	300,000
40,000	"	" " "	11	10	22	80,000	"	" " "	11	8	21	80,000
40,000	"	" " "	25			171,625	"	" " "	25			175,084
40,000	"	" " "	30			229,664	"	" " "	30			235,297
40,000	"	" " "	34	6	28	300,000	"	" " "	34	1	8	300,000
45,000	"	" " "	11	10	22	90,000	"	" " "	11	8	22	90,000
45,000	"	" " "	25			193,073	"	" " "	25			196,969
45,000	"	" " "	30			258,375	"	" " "	30			264,719
45,000	"	" " "	32	6	20	300,000	"	" " "	32	1	12	300,000

Another statement prepared by a member of the Committee, shows the results of paying to a company an annual increasing sum for hydrants as proposed at $40 each.

Commencing with 130 Hydrants, the least number supposed necessary,* and increasing 10 every year for twenty-five years, the aggregate cost at $40 each would be $250,000, and the sums paid computed at 6 per cent. compound interest, would amount to $513,484 52. It will be seen that at a price for each Hydrant but little more than half of that assumed, the amount would equal the estimated cost of the whole water works.

The following calculation may have slight errors, but is substantially correct.

130 Hydrants	at	$40=$5,200	am'ts.	at comp'nd	interest in	25	years	to	$22,322 90
140	"	" 5,600	"	"	"	24	"	"	22,679 27
150	"	" 6,000	"	"	"	23	"	"	22,923 82
160	"	" 6,400	"	"	"	22	"	"	23,068 00
170	"	" 6,800	"	"	"	21	"	"	23,122 44
180	"	" 7,200	"	"	"	20	"	"	23,096 73
190	"	" 7,600	"	"	"	19	"	"	22,999 90
200	"	" 8,000	"	"	"	18	"	"	22,840 02
210	"	" 8,400	"	"	"	17	"	"	22,624 54
220	"	" 8,800	"	"	"	16	"	"	22,360 30
10 years,		$70,000							$228,037 92

* The number of Hydrants in Boston is 1110.

Brought forward,	$70,000				$228,037 92
230 Hydrants at $40=	$9,200	am'ts. at comp'nd interest in	15	years to	$22,053 47
240 " "	9,600	" " "	14	" "	21,709 74
250 " "	10,000	" " "	13	" "	21,334 26
260 " "	10,400	" " "	12	" "	20,931 73
270 " "	10,800	" " "	11	" "	20,440 79
280 " "	11,200	" " "	10	" "	20,057 84
290 " "	11,600	" " "	9	" "	19,597 94
300 " "	12,000	" " "	8	" "	19,126 17
310 " "	12,400	" " "	7	" "	18,661 68
320 " "	12,800	" " "	6	" "	18,157 03
330 " "	13,200	" " "	5	" "	17,664 57
340 " "	13,600	" " "	4	" "	17,169 68
350 " "	14,000	" " "	3	" "	16,674 22
360 " "	14,400	" " "	2	" "	16,179 84
370 " "	14,800	" " "	1	" "	15,688 00
25 years,	$250,000				$513,484 52

From these two statements it appears that if the City own the works, and issue its bonds for $300,000 to construct them, payable in thirty-six years; it may receive from $37,500 to $45,000 as a premium, which sum* put at compound interest, as a sinking fund, will pay the whole cost of $300,000 before it becomes due. The City will have to pay the annual interest and expenses, but will have the income of the water rates, to pay with; and *in less than thirty-six years, the City paying only the interest, will own the whole water works free from debt or incumbrance!*

But if a company own the works, the City must pay the company $40 a year for each hydrant, beginning with 130 costing $5200 the first year, and gradually increasing, till long before the thirty-six years, *it will have paid more than the whole cost of the works,—including interest, more than double the cost,—and will then own not a cent in the works!*

A statement might also be made showing the effect of an abundant supply of water in diminishing the rates of Insurance; in greatly diminishing the losses by fires; in multiplying steam engines, and all the various kinds of business, and labor connected with them; in rendering the City more desirable as a place of residence to strangers, thus increasing the population, the wealth and value of Real Estate in the City.

The losses by a single fire (the great fire of 1835) in the City of New York, before the establishment of the Croton Works,

* The least premium mentioned, 12½ per cent., will cancel the debt in less than 36 years—a less or greater premium will lengthen or shorten the time in proportion.

would alone pay for all the immense expense of these works. In a time not far distant a single fire in New Haven may destroy property of greater value than the cost of our proposed works, which property with the water works might be saved.

Another member of the Committee acquainted with the streets and business of the City, has prepared the following estimate of the probable income for the first three years.

Estimated Receipts for Three Years.

1*st Year.*—Water Rents from Railroads, from $1000 to 1500, . .	$1,000
Estimating that twenty miles of distributing pipe are laid in the City, and that there are within these limits 2,000 dwelling-houses, and 250 stores, making 2,250, from which if one-sixth rent the water, 375 in number, at rates varyiug from $5 to $20 each, average $10, ...	3,750
Water Rents from Hotels, Manufacturers, Livery Stables, and private stables, 1st year, ...	1,500
Rents from Bathing Houses, Gardens, and all other purposes, . .	750
	$7,500
One hundred and forty Hydrants for use of the City, one at the intersection of every street within the limits of twenty miles, at $40 each,—this price is based on what is supposed the City would be charged for each Hydrant by a Water Company, if supplied in that way, and would be charged in current expenses, ...	5,600
For one year, ...	$12,600
2*d Year.*—Water Rents from all Railroad Companies for the year, estimated at from one to two thousand dollars, say, ...	1,300
Water Rents from Dwelling Houses and Stores within same limits, including a low estimate for increase of buildings, 2175 dwelling-houses, and 275 stores, making 2400, from which estimating that one-third receive the water, 800 buildings in number, at from $5 to $20 each, averaging $10,	8,000
Rents from Manufacturers, also from Hotels, Livery Stables, and private stables, for the 2d year, ...	2,500
For Bathing Houses, Gardens, &c., ...	1,000
One hundred and fifty Hydrants for City use, at $37 50, . . .	5,625
For two years, ...	$30,025
3*d Year.*—Water Rents from all Railroad Companies, ...	1,500
Water Rents from Dwelling Houses and Stores, 2225 dwellings, and 275 stores, making 2,500, from this mumber estimate one-half, 1250 buildings, furnished at from $5 to $20 each, averaging $10, ...	12,500
Water Rents from Hotels, Manufacturers, and public and private stables,	3,500
Water Rents for Bathing Houses, Gardens, &c., ...	1,500
" " for one hundred and sixty Hydrants for City use, at $35 each,	5,600
For three years, ...	$54,625

The interest on $300,000 for three years is $54,000, and from the above estimate the receipts exceed the interest for three years $625.

But the income is not the only consideration. The great increase of the wealth and resources of the City that will result from a liberal and cheap supply of water; the augmentation of its productive capital and productive industry;—of its taxable personal property and the value of its taxable real estate, immensely increasing the resources of the City, and its ability to provide for its wants, and to pay its obligations, present considerations that make any income from the water rates, or any probable water tax comparatively unimportant. When the water shall be liberally and cheaply supplied to the citizens and their families, to public houses, schools, private and public baths, gardens and fountains, stores, manufactories, machinists, steam engines, rail roads, shipping, &c., the income from the works will indeed exceed expectations; but the impulse that will be given to the growth of the City, to the sources of its business and wealth and prosperity will exceed all calculations.

A project involving such great interests should not be allowed to go out of the control of the City; and the public health, the public safety, and the public prosperity, should not be hazarded by entrusting them to a system conducted only to promote private interest, instead of a system conducted only for the public good.

Some favor the idea of allowing the works to be constructed and owned by a company at first, with a condition that they may be ultimately purchased by the City. Whatever differences of opinion there may be on this question, there is no doubt among those who have examined the subject, but the City ought to own the works in the end.

The first reason for entertaining this idea is that the City is not willing to undertake the works. This question can only be decided by submitting it with all the facts and considerations to the City for its decision. The City ought certainly to have the opportunity to make this decision.

The second reason is, that it will be more economical. But will it be sound economy in the end?

The interest of a company under such circumstances would be to construct the works in the cheapest manner for a temporary purpose; to produce the best income on the cost, for a few years, till purchased by the City. The City would then be obliged to pay the costs, the interest, and the profits of the contractors which are sometimes enormous, for works cheaply constructed, probably in such a condition that they would have to be rebuilt at an expense far greater, than if the City had in the first place built them in a substantial and perfect manner.

In addition to this no company would be willing to make a contract to surrender to the City at any time unless with the proviso that it should be paid not only for its own estimate of the costs and interest, but a large sum for the risk it had encountered.

No company will undertake the work unless with the prospect of large profits in some way. If a company can make it so profitable,—why not the City?

It is supposed by some that a company can build and manage the works at less expense than the City would. Undoubtedly they can, and probably would, for the reasons before stated, because their works would be less perfect and substantial. But there is no sound reason why the City of New Haven cannot build as good works as any company, and as cheap of the same quality. In other cities there may have been an expensive mode of doing public business, which has given rise to this opinion. But not so has been the practice in New Haven. Its public works have been as well built, and at as little cost, as they could have been built by individuals or a private company. Was not this the case with our new Alms House, our new McAdamized road to Westville, our fence round our Public Square, our walls and iron railing round our public Cemetery? Any person who will examine these works and their bills of costs, will be satisfied that rarely, if ever, were works of equal value built at so little expense, either by public or private funds.

The whole business of constructing water works has become by experience so well understood, that the costs can be ascertained beforehand with great precision; and contracts can be made and executed without risk, and without loss, by a city, as well as by individuals. The more this matter is examined, the

more it will prove that a city, at least New Haven, is quite as likely to build its water works well and economically, and for its own permanent welfare, as a private corporation, whose whole object is, by its management, or by its contracts of enormous profits, or in some other mode, to make money.

The opinion that the water works should belong to the City, and not to a private corporation, is sustained by the advice of almost every person of experience, who has been consulted.

The following letter from Nicholas Dean, Esq., the President of the Croton Water Department, New York, a gentleman of great experience and great ability, presents the question in a strong light, and most forcibly expresses the general opinion received from other men of science, and practical experience who have been consulted.

In reply to a letter asking his opinion, 1st, whether the water works should belong to a company, or to the City; 2d, what were the chief causes of the waste of water in New York; 3d, whether a company could more effectually prevent waste than a city; he writes as follows:

"Croton Aqueduct Department, New York, Jan. 21, 1853.

"Dear Sir,

"Your favor of the 19th inst. was received on the 20th, and I take the earliest moment to reply briefly to the questions propounded.

"To the first, I answer without hesitation, and most emphatically, that the supply of water cannot with safety be placed in any other hands than those of the City itself. No act of incorporation of a company could be so drawn as to protect *all* the interests, public and private, involved in the daily and regular delivery of this most indispensable element of business, of health and of life. The pecuniary returns of such company,—and this must always be its governing motive,—would often conflict with the public necessities, and throw obstacles in the way of the City government in conflagrations, and especially in seasons of disease and pestilence, when the almost unlimited use of water becomes necessary.

"London and Baltimore are now suffering the consequences of being subject to the dominion of companies chartered to furnish water to those cities. With the former I have been in correspondence, on this subject, for more than three years past, and know the efforts made to purchase out the different water companies heretofore created there. A Parliamentary commission has been raised for this object, aided by a number of the most influential citizens, but up to the date of my last advices, no satisfactory progress had been made. The prices demanded as an equivalent for their privileges were so enormous, as even to stagger the wealth of London, and its inhabitants are yet compelled to receive the weekly quantity doled out by these companies,—while its quality is often disgustingly filthy. Could the city have succeeded in the proposed arrangement, it was intended to have built an entire new set of works, after the plan of our Croton Aqueduct, taking the water from the Thames fifty miles above the city, giving a head of one hundred and seventy feet, from a source comparatively pure. So also in Baltimore, similar efforts have been made, and are still being made; delegations from the city councils have twice visited us in relation to this matter, and the unanimous opinion of these gentlemen, derived from *experience*, is against the policy of ever committing so important a subject to the control and supervision of a company.

"In my opinion, it would be just as wise to trust the daily food of your citizens, their bread, and their beef, to be supplied under a special charter granted for that purpose.

"With the experience now had in Hydraulic engineering, the cost of every portion of the work necessary to supply your city with water, may be known with great accuracy; the whole is reduced almost to a scale of prices, and the city government can do the work as expeditiously, and as cheaply as a company could do it; wherefore, then, place a work of such magnitude, connected in the future so intimately with the daily life, comfort, and convenience of every citizen, in any hands beyond the immediate and instant control of the municipal government? Its revenues to the Treasury should not, from the commencement, be measured by dollars and cents, though these would in a brief space, no doubt, equal the interest upon the cost,—but rather in

reference to its present and prospective influence upon the growth of your City, and the productive industry of its inhabitants; these, especially the latter, would be increased to an extent not imagined even by the most sanguine. The few steam engines running in this city in 1842, previous to the introduction of the waters of the Croton, have been multiplied till they reach many hundreds, and thousands of our people are fed and clothed by labor dependent on them, while the taxable value of the personal estate connected with and derived from them, is indicated by millions!

"Such are the general and enlarged views which should enter into,—and, may I not add,—govern your deliberations. Should, unfortunately, other counsels prevail, and the City permit such a franchise to pass beyond its control, I predict that in ten years but one expression of universal regret will be heard.

"In regard to the waste of water, I may say, that our chief difficulties have arisen from erroneous city legislation in the early stages of the distribution of the water; the subject was imperfectly understood; the sources of supply were thought to be inexhaustible, and as a consequence, more and larger taps were granted to consumers than their legitimate wants required; *free* street hydrants, to the extent of many hundreds, were placed throughout the city, and left continually running, and those little fixtures on the side-walk in front of every dwelling, known as window, or street washers, were multiplied beyond precedent, with leave by ordinance to use them, *ad libitum*, before 8 A. M., and after 7 P. M., during the whole summer. These are but a few of the blunders originally committed, which with lapse of time, have assumed the character of *vested rights*, and are now difficult to abate, or amend. The result is, that the estimate made by the Commissioners under whose directions the aqueduct was commenced, of twenty-two gallons of water per diem, to each individual, has grown and expanded, till we are now serving nearly ninety gallons!

"In naming the preceding sources of waste, I have purposely omitted those arising from our immense mercantile marine, and occurring along our wharves, at ferries, and steam boat berths; so also, of underground connection of buildings with public sew-

ers, through which enormous waste of water is effectually concealed,—because these would not yet apply to your City.

"I have made this reply to your letter as full as other duties will, at this moment, permit, and only add, that well devised city ordinances will more effectually control the use and abuse of all the benefits to be derived from a full supply of water, than can any by-laws, or rules emanating from a corporate company.

"Most truly and respectfully, Sir,

"Your Friend and Servant,

"NICHOLAS DEAN, *Pres't.*

"Hon. A. N. Skinner, *Mayor, &c.*"

Of a similar character are the following extracts from two communications made to the Common Council of Boston, by Hon. Samuel A. Elliot, Mayor of that city, at the time the water question was there under discussion:

In a Report of the Committee on the introduction of pure and soft water, made in January, 1838, the following remarks occur:

"The question is whether it is expedient for the City to undertake the work, or to entrust the execution of it to a private company, with the privilege of purchasing their rights whenever it should be deemed expedient. On this point the Committee entertain no doubt* that it is best for the City to execute the work by its own agents, and to have the control and superintendence of it from its commencement to its completion. They believe that it is too important a business to be suffered to be affected by the calculations of private interest, which it is certainly possible might be injurious to the permanent character of a work which ought to be begun with reference to the future wants of a great and growing city. If, in order to prevent this evil, it should be stipulated that the work should be done to the satisfaction of agents appointed by the City, there would be another danger, viz.: of collision between different interests, and of delay in the prosecution of the business which, if undertaken, ought to be completed as speedily as consistent with the durability of a

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* It is intimated in another sentence that the Committee were not unanimous, though nearly so, on this point.

structure designed for the benefit of posterity as well as ourselves. Another reason why the City should undertake it, independently of all private interests, is that the expense of the operation to the community would be less. Should the City have the privilege of purchasing, if they should find it advisable, it would probably be on the usual condition annexed to such privileges, of paying 10 per centum per annum on the investment. But if the City perform the work, they can, without question, obtain the money at five per centum per annum; and thus, if at the end of ten years the City should purchase the works, it would be at a loss of five per centum for ten years on the cost, which, whether paid by one corporation or the other, would probably not fall far short of a million and a half of dollars. In ten years, therefore, the work may cost the City $750,000 more, if performed by a private corporation than if done by itself. If it should prove possible to accomplish it for less money, still the argument is valid in proportion to the amount actually expended."

"But it may be contended that it may never be necessary to purchase the rights of the corporation. In that case the citizens would always be liable to a higher rate of taxation [for water] than the City would charge; as it is not to be supposed that a private corporation would supply the necessary quantity at as liberal a rate as the City, who can have no other interest than to provide water at as low a charge as will cover the necessary expenses."

In a subsequent Report, presented in September, 1839, the following passage occurs:

"The only other objection of which the Committee are aware, which has been urged against the plan of this great work, is that it would be done with more economy by a private company; and that if the City perform it, it will at a loss of all the outlay which would be saved by individual prudence. But it must be recollected that a private company would not undertake a work of this kind without a pretty sure prospect of profit, and that consequently it must be guaranteed against competition for a term of years. It would, therefore, be for its interest to construct the works of such size and strength only as would be sufficient for that period, and when the public came into possession of

them, they might require almost entire renewal. But supposing they were constructed in the best manner, it is clear that there must be a profit secured to the company, or at least they must calculate on it with some confidence; whereas, if the City do the work, they may reap all the benefit, or save the charges which are to make the profit of individuals. Then the work is of such a character, and involves so many interests connected with the streets, the Fire Department, and various other branches of the public service, that if entrusted to private hands, there would be constant danger of unpleasant collisions, and injurious controversies with the City authorities. It ought, therefore, in the opinion of the Committee to be confided to the care of the same persons who are entrusted with the other public interests."

From all the persons who have been written to, without an exception, similar opinions have been expressed. It is but fair to add that, in two instances, out of many, the opinion was expressed that a company might prevent waste when the supply was small. But both still expressed the opinion that the City ought to own the works.

In view of the information before them, the Committee are of opinion, that the supply of the City with water is a matter of too great importance to be placed under the control of private interest; that the efficiency of the Fire Department, the interests of the citizens, the health and prosperity of the City, and both private and public economy require, that the City should keep so important a trust under its own control.

In conclusion, the Committee are of opinion:

1st. *That the water works should be constructed, and owned, and controlled by the City.*

2d. *That water power is to be preferred to steam power for this purpose.*

3d. *That of the various plans examined by the Committee, those described in this Report as,*

No. 1. *Mill River by water power,*

No. 2. *Quinnipiac by Whitneyville,*

No. 3. *Quinnipiac by Cedar Hill,*

are from present information, to be preferred; but that it may be wise to defer a final decision between them, for further consideration and investigation.

The Committee recommend;—that a City meeting be called within four weeks after the publication of this Report, and that the following propositions be submitted for the decision of the citizens: that on the final vote the polls be open from 8 A. M. to 5 P. M., to receive the ballots, on which the words YES or NO, or words equivalent, as YEA or NAY be printed or written; and that two boxes be provided, marked respectively No. 1, for the first proposition, and No. 2, for the second proposition; that the votes be counted in the manner usual at the annual City elections, and the result certified by the Presiding Officer to the City Clerk, for record.

First Proposition.—Are you in favor of procuring a supply of water for the City of New Haven, to be brought at the expense of the City, from the Quinnipiac, or Mill River, or elsewhere as shall hereafter be decided; on the condition that those of the inhabitants, who may elect to take and use the same, shall be required to pay for the water such reasonable tax as shall hereafter be fixed and established by a Board of Water Commissioners that shall be created; and on the condition that contracts can be made for the execution of the entire plan that shall be selected, for a sum not exceeding $325,000?*

* The sum of $300,000 was first adopted, but afterwards changed to $325,000, to provide for contingencies and part of the interest for one or two years.

Second Proposition.—Do you hereby vote to instruct the present Water Committee to apply to the Legislature, in behalf of the City, for such additions to the Charter of the City, as shall provide for the transfer of the rights and privileges of the New Haven Water Company to the City; shall prescribe the mode of election, tenure of office, and powers of *a Board of Water Commissioners* who shall construct and manage the works; shall prohibit any moneys that shall be set apart for a Sinking Fund to extinguish the water debt, from being applied to any other purpose; and shall grant such other powers as shall be proper to carry into effect the objects expressed in the first proposition?

All which is respectfully submitted.

A. N. Skinner,
Henry White,
Ezra C. Reed,
Charles A. Ingersoll,
Matthew G. Elliott,
Henry Hotchkiss,
Wm. H. Ellis,
Henry Peck,
Elias Gilbert.

February 10, 1853.

ENGINEER'S REPORT

To the Committee of the City of New Haven for Supplying Water.

To Hon. A. N. Skinner, Chairman ; and Henry White, Ezra C. Read, Henry Hotchkiss, Henry Peck, Wm. H. Ellis, Elias Gilbert, Charles A. Ingersoll, and Matthew G. Elliott, Esquires, Water Committee of the City of New Haven.

The Engineer to whom was committed the surveys and investigations respecting the means and expense of supplying the city of New Haven with water, respectfully Reports—

There are around New Haven, and within reach, several sources of moderate supply, in addition to the more copious streams, and which, at first view, might appear entitled to a prominent attention. On the East, is the Saltonstall's Lake, that might be made, although at much expense, to receive, as a reservoir, the waters of Farm River, affording together, upon conjecture, eight millions of gallons* per day.

On the North-West, distant but one mile, are the Beaver Ponds, covering a considerable fraction of a square mile, and having in their least copious condition a daily flow closely approximating to 2,600,000 gallons of apparently pure water. To the North, above Mount Carmel, lie the head streams of Mill River, twelve miles distant, but pure and of sufficient elevation to flow down by gravity to the amount of two or three million gallons, under sufficient head, and capable of increase by artificial, though expensive collection and storage, to a yet larger amount, probably four or five millions.

* By gallons in this Report, the standard of the United States (231 cubic inches) is always to be understood, unless otherwise specified.

Thirteen miles to the North-East, is the stream miscalled "Muddy Brook," affording at its minimum two and a half millions of pure water at an elevation, if taken out above Tyler's Mill, sufficient for conduction and for service of the city. And in addition might be mentioned the streams at or around West Rock and from the highlands of Woodbridge. But a sufficient reason will appear for bestowing on most of the foregoing only the slightest attention.

For, in the first place, as respects Saltonstall's Lake, the intervention of a navigable water cuts it off, together with the Farm River, from competition with supplies far more copious as well as convenient in situation and distance. The Lake, in the highest stage to which it might be brought if made a storing reservoir, would be but 25 or 30 feet above mean tide.

With respect to the Beaver Ponds, also, there would be no alternative but to elevate by steam, and two mill privileges would be destroyed and a third injured by the abduction of the water. If taken at all it should be below the factory of E. W. Blake, Esq., in union with other waters.

The waters from above Mount Carmel have the great advantage of a natural head. They might be conducted to a reservoir upon the slope of West Rock and augmented on their passage thither by several brooks or springs. But the route is long and costly, and the number of proprietors to be arranged with is a second discouragement—at least until some other means of supply shall have been attempted in vain.

Another resource is Muddy Brook, which has been made the subject of examination and an estimate that will herein be given, on account of its valuable property of supplying its own head for conduction and distribution, as well as its capacity to be made auxiliary to another and far more prominent stream. There are, however, at this time, five mill privileges improved below the place from which this flow must be taken out, all of which would be destroyed by the supposed appropriation of the water.

But there is an obvious and prominent fact and circumstance which throws all the smaller supplies into the shade, except as they may be made auxiliary to the larger. For it should be

considered in the outset, that after passing the strict necessities of the person and of the household, the quantities in which this element of life and comfort will be used for purposes of salubrity, neatness and luxury, will be increased a hundred fold when it comes self-conveyed to the chamber or the garden, and may be thrown in refreshing and purifying abundance upon the sidewalks, streets, foliage and buildings. It should be considered, also, that what is now a desideratum simply is hereafter certainly to be a commanding necessity for all coming time, and that the demand will augment with that growing population to which the execution of this project will itself largely contribute. The increase of this city from eight thousand to the present twenty-five thousand, lies in the compass of a brief memory, and of those who shall retain the incipiency of the project now under consideration among their reminiscences, there are many, no doubt, who will witness the twenty-five thousand grown up to sixty or eighty thousand. In fact it would be obviously short-sighted not to look for streams copious enough for a hundred thousand inhabitants at least, and better still for two hundred thousand, if such can be improved for the present object without an objectional expense.

Amount of Water Required.

The quantity required for the supply of cities was minutely discussed in the ample Reports of the Engineers, Jervis and Johnson, Water Commissioners for Boston, in 1845, and concluded from the concurrent experience of London and Philadelphia, to be on an average of the year thirty gallons to an inhabitant and forty gallons at periods of extraordinary drought and heat. The actual average in Boston, however, proved to be, during the hottest part of 1851, fifty gallons to an inhabitant. In New York it has been sixty gallons, and has risen in some days as high as ninety—an expenditure that was undoubtedly wasteful.

The large expenditure in the foregoing cities for street washing, would not for a long time to come be required to the same extent in New Haven. On the other hand, the deduction

properly due to this may be more than balanced by the quantities that would be profitably employed and soon become indispensable for the gardens, grounds and foliage, which constitute one element in the combination of qualities to which this city owes its celebrity. From the foregoing facts and considerations, it would seem to be a just inference that a supply of forty gallons on an average, and of sixty at extraordinary periods, is not essentially more than a prudent foresight demands, looking to a supply for twenty-five thousand inhabitants at this time—or one million of gallons per day, and arranging works that may be pushed to a duty of two and a half millions—or the ordinary supply for sixty-two thousand five hundred inhabitants—providing also for a future enlargement adequate to supply one hundred thousand inhabitants at least, or, perhaps, two hundred thousand. This would exceed nearly three and six times the capacity of our smaller streams and fountains, but not of our larger.

Capacity of the Larger Streams.

The period at which your Engineer commenced his investigations, proved to be a specially safe one for the determination of reliable quantities, since the flow in July, August, and the early part of September, in this year, has been less, as has appeared by the united testimonies of the operatives at the mills and factories on all the water courses, than in any year of a long series preceding.

The streams, however, are almost universally occupied through their lengths by factory dams, which, throwing down irregular quantities in the day and retaining the flow at night, made the operation of guaging a laborious and critical one. With respect to the Quinnipiac, it was, however, found that the suspension of work from Saturday night to Monday morning, allowed the entire stream to pass all the dams by leakage and overflow, except the small branch from Black Pond in Meriden, which was all retained above the upper factory.

By repeatedly improving the earliest light of Monday, before any machinery was in motion, consistent and reliable results were obtained, and the small branch above mentioned was

guaged separately and added. By a comparison and average of three such guagings made, immediately below the Quinnipiac factory, between July 26th and August 23d, it appears that the Quinnipiac, at its minimum flow in the driest season, may be relied upon to supply fifty cubic feet per second through the twenty-four hours, being in round numbers thirty-two millions and one-third gallons per day.

As the flow of Mill River was not sufficient to fill and overflow some of the factory dams, it became necessary to obtain it from day to day, through the twenty-four hours, at some point near that from which the water would be taken. A position immediately below the bridge, south of Waite's dam, was selected, and by a comparison and average of three days in the close of July, it appeared that the Mill River may be relied upon at that spot for eighteen cubic feet per second; or, in round numbers, eleven millions and two-thirds gallons per day.

The above measurements were tested by a separate guaging at the raceway of Churchill's factory and the leakage and springs at the foot of his dam. The work here being uniform and continued through regular hours from day to day, it was possible, by a single guaging, to approximate closely to the natural flow at that locality. This guaging, made on the 30th of July, gave fifteen and two-thirds cubic feet per second; or over nine and two-thirds millions of gallons per day.

I may add that Muddy Brook was visited repeatedly and guages taken; but the results were made irregular by the unequal discharge from the dams. All that could be determined in a general way, proved to be four cubic feet per second at Tyler's mill—or nearly two millions six hundred thousand gallons per day as above stated.

The main Beaver Pond at its outlet, when not affected it is believed by the dam below, was found to discharge just four cubic feet per second, or the same as Muddy Brook.

The mingled and united waters of the Beaver Ponds, and the streams coming down from the North and West, on both sides of West Rock, were guaged by Mr. Michael Ritner, Principal Assistant on the survey, on the 29th day of September, and found to discharge eighteen cubic feet per second; but rains had

intervened since the drought and the flow was doubtless swelled by the works above. Twelve cubic feet per second is probably a large estimate for the minimum flow above Jacock's mill,—and would require confirmation by new and continued guaging and comparison with the streams whose minimum is known.

Head required and Size of Conduits and Pipes.

For buildings it would be sufficient if the effective head were two or three feet above the highest points required to be supplied. But for the more copious uses, for fire hydrants and irrigation, no attainable amount of head will be excessive. As the water must be elevated by mechanical means, an additional burden is imposed by additional height, and the strength of pipes employed for distribution must also be in due proportion. The head attainable in our circumstances, does not exceed by more than twenty feet the lowest elevation perhaps that can be supposed. For the present estimate the former will be contemplated and a sum stated afterward in the way of deduction that will reduce the latter.

The crest and dividing slope between the Quinnipiac and Mill River, along which the waters of the former are to be conducted for four miles, has an elevation in the North of one hundred and forty feet, descending to one hundred and thirty-five in the South, with one depression of twenty-five feet for half a mile. The ridge (Sachem's Hill) West of Whitney Avenue, reaching from Mill Rock to Sachem's Wood, exhibits a crest of from one hundred and twenty to one hundred and fifty-eight feet above mean tide. The greatest useful elevation to which the waters of the Quinnipiac could be thrown by pumping, would be one hundred and forty feet; which at the reservoir by the Toll Gate is reduced to one hundred and thirty-five feet, and at times to one hundred and thirty, and at the city centre one hundred and twenty-five to one hundred and thirty above mean tide, according to the condition of the reservoir.

But in fires this head would be diminished yet more, some ten feet, by the greater velocity in the pipes. At an extreme depression of the reservoir, it might be counted as about one hundred and fifteen feet above mean tide. The parts of the city east of

Church street being from fourteen to twenty-two feet above mean tide, and the western parts from twenty-two to forty-five, the head, in case of a great fire, would average about one hundred feet in the former instance, and about eighty in the latter.

To give the above supplies two mains, twenty-one inches in diameter will be required from the reservoir to the heart of the city. A smaller diameter by one inch or more would suffice, were it not that an incrustation forms in the interior and reduces the capacity to that extent. In duplicating the pipes there is safety ; for if one should fail the other would supply in whole or in part. A short supply is a calamity unmeasurably less than absolute privation even for a few hours. The introduction of water will be followed by ranges having an enclosure at the back where water is constantly heated by the ordinary fires. In these no fire can long be maintained safely without the presence of the included water, so that the absence of water must extinguish the fires also. For these and similar reasons, extraordinary precautions against accident must be taken as respects every part of the arrangements.

A conduit of oval shape, with diameters of three feet horizontal and four vertical, and with a fall of one foot to the mile, will conduct, when half filled, all the water required for a long series of years. It is to be made of brick eight inches thick, and well lined with hydraulic cement within. Its crown will be covered at least three feet with earth. In cutting the soft red sand rock, I propose to use the cut for the lower half of the conduit—arching the upper half and lining the whole as above stated.

Modes of Supply.

The only modes that appear to your Engineer worthy of special attention, in view of all the considerations, are the five following :

First. To divert the Quinnipiac, or so much as shall be required from its present channel into a canal leading from the present Quinnipiac factory to the vicinity of North Haven. From the southern end of this Canal to pump the water by the power of the stream into a reservoir on the ridge west of the valley, and convey it by a conduit to a distributing reser-

voir, on the brow of the ridge three miles from New Haven, near the present Toll gate, on the Hartford Turnpike; from this the distribution will be made by the pipes into the city, along the turnpike.

Second. To set back Mill River to the foot of Churchill's dam, by a new dam and embankment below the present Clock Factory—by an open canal to lead the stream, or so much as shall be required through the point of Mill Rock, near the Gun Factory, and around the bay of low land to a site back of the present dwelling of Eli Whitney, Esq. From this it will be pumped by the power of the stream to a reservoir on Sachem's Hill, west of the works to be erected—and thence distributed by pipes into the city, a mile and three quarters distant.

Third. To pump the water by steam from below the Gun Factory into the reservoir upon Sachem's Hill, last mentioned, and thence distribute as before.

Fourth. To take the requisite supply from the pond above Churchill's dam, and conduct it three miles by an open channel through Pine Brook Valley, to a position behind or south of Mill Rock, and on the west of Sachem's Hill, and pump by steam power into the reservoir, last mentioned, through mains ascending to the east.

Fifth. To pump by steam from the united streams at Westville into a reservoir upon the Beaver hills, about one mile and a half from the centre of distribution, and distribute by pipes along Goffe street or Whalley avenue.

Before considering these plans separately in detail, it may illustrate the general subject to consider by themselves the two items of reservoirs and lifting power.

Reservoirs.

The localities near the Toll house and on Sachem's Hill admit of reservoirs of almost any capacity that may be desired. But while it may seem prudent to obtain at the outset an area of land ample for all the future, it will be unnecessary at present to contemplate more than ten or twelve days supply. This may be done by a construction 550 feet long at high water line, and of half the breadth, and capable of being drawn down ten feet. The containing embankments are to be seventeen feet above

bottom and twelve feet wide on top, with slopes of two to one on the outside and one and a half to one within ; puddled in the middle above high water line and on the bottom, which, as well as the inner slopes is paved in brick, set in hydraulic cement. Inlet and outlet chambers with gates and pipes are to be provided—also a waste well and conduit and a connecting culvert through that side bank which by future addition of the other half of the square will become the partition of the reservoir. At present there will be no partition, but the conduit or rising mains will be continued to unite with the distributing mains in case it shall be necessary to draw off the reservoir for cleansing.

By reason of the greater proximity of Sachem's Hill reservoir, compared with the Quinnipiac reservoir, a head somewhat less may be admitted in the former instance, compared with the latter. If this is 135 feet, that may be 132, and yet be equally efficacious, everything considered.

The site for a reservoir on Beaver Hills has not been accurately surveyed. From a rude examination it seems probable that the water line cannot have an equal elevation with those before mentioned by ten feet, unless at a largely increased expense.

Estimate of Reservoir on Sachem's Hill.

36,000 cubic yards of earth, $13\frac{1}{2}$ cents,	$4,860.00
12,000 cubic yards of puddling, $38\frac{1}{2}$ cents,	4,620.00
7,000 cubic yards of puddling, 30 cents,	2,100.00
1,350 cubic yards of paving and lining, $6,	8,100.00
Turfing and Facing,	1,250.00
Land and Graveling,	1,850.00
Influent house and gates,	1,500.00
Effluent house and waste well and conduit,	3,250.00
Water channel exterior,	100.00
Connecting culvert and gate,	1,640.00
Inlet and outlet pipes and stop cocks,	1,300.00
600 feet conduit for connecting mains,	1,500.00
Pipes and stop cocks for connecting mains,	430.00
Entire cost,	$32,500.00

The Quinnipiac reservoir, although varying in details of earth and rock, presents very nearly the same items and resulting cost.

LIFTING POWER AND MACHINERY.

1*st. Water Power.*

It has been stated already as an obvious arrangement, in case the entire control of the Quinnipiac, or of Mill River, shall be obtained—or, at least all that the city shall require for any future period, however distant—to employ the main stream or so much as shall be requisite to elevate the supply into the adjoining reservoirs. The flow of the Quinnipiac at a minimum was found to be fifty cubic feet per second. Of this three feet and a half per second would be lost by the excess of leakage and evaporation in the canal above the small supplies from the entering springs and brooks. The evaporation and leakage of the water pumped up would not probably exceed the supply from Bronson's brook, and three other small fountains that empty into the reservoirs above. Deducting the supply to be lifted and giving the additional head due to friction in the pipes, we have $42\frac{1}{2}$ cubic feet with a head of $19\frac{1}{2}$ to lift $4\frac{1}{2}$ feet $121\frac{1}{4}$. This is over two millions nine hundred thousand gallons per day—nearly three times the present necessity. In ordinary seasons, the river at its minimum flow would be competent undoubtedly to throw 3,600,000 gallons, and by the establishment of reservoirs, might be made competent to so much, and more in every season. If two turbines are erected in the first instance competent to throw 1,200,000 gallons each in twenty-four hours, they will easily perform by day-light the work now demanded, and afford the supplies for accidents and exigencies. Ultimately a third may be added and afford the ordinary supply for 90,000 inhabitants before a necessity for steam or any other mechanical agency will arise.

At Mill River, under similar conditions, we have two cubic feet lost by evaporation and leakage from the pond and canal—leaving sixteen per second, for supply and work. The head would be 34 feet and the lift and friction $98\frac{1}{2}$. Under these circumstances, 3 feet per second almost exactly could be raised

by the remaining 13 feet. This is a supply of nearly 1,900,000 gallons, not quite adequate for 50,000 inhabitants. But the stream in ordinary seasons would exceed this, and by the assistance of reservoirs, as in instance of the Quinnipiac, might be made reliable for a greater amount. I propose here two turbines, as at the former stream. In both cases the expense may be assumed as follows:

Two turbines with pumps to throw 1,200,000 gallons each in twenty-four hours, . . .	$13,000	
Wheel and pump house, . .	5,000	
Race pump, well and road bridge, .	3,965	
		$21,965
Engineer and assistant, $3.50, .	$1,277.50	
Repairs, fuel, lights, &c., . . .	75.00	
Insurance, ...	125.00	
	$1,477.50	
The Capital to maintain this, at $6\frac{1}{100}$, . . .		24,625
Total for lifting 1,000,000 gallons and machinery for 2,400,000 gallons, . . .		$46,590
If the head were diminished twenty feet, the above total might be reduced to . . .		$44,290

2d. Steam Power.

At the "Spring Garden and Northern Liberties'" works, at Philadelphia, the water is pumped 115 feet by three steam engines, capable of raising 2,400,000 gallons each in twenty-four hours, the cost of each engine being about $15,600. In these steam is cut off at half stroke; but in the engines used for cleaning the mines of Cornwall in England, steam is cut off at a small fraction of the stroke, the cylinders being made large, and the connections strong. By thus carrying the principle of expansion to its practical limit, those engines are made to realize a performance double of the ordinary engines. Although therefore the Cornish engine is far the most expensive, there is great economy in its use, and in the works now in progress in this country, it is coming into universal employment.

The data for estimating the expense of the engine, or its performance in our own cities, are not so abundant as could be wished, but may be concluded with a sufficient approximation and certainty from the English data, as they appear in the Report of the Boston Water Commissioners, and from comparison with ordinary engines, and by allowing for the requisite variations. The work to be done by the two turbines at Mill River, I should propose to make the duty of a single Cornish engine of capacity to raise 2,400,000 gallons 132 feet high, in twenty-four hours, but to tax it at present only by day, and for 1,000,000 gallons. For safety against accident, a second engine of ordinary construction may be provided, capable of raising 1,500,000 gallons in twenty-four hours, but not ordinarily to be in use. The cost and capital to cover current expense of operations at Mill River may thus be stated:

Engine-house, boiler-house and chimney,	$7,500	
A Cornish Engine with pumps as above,	23,000	
An ordinary Engine with pumps as above,	12,000	
Basin pump, Well, &c.,	5,940	
		$48,44 0
Coal to raise 1,000,000 gallons 132 feet high per day, 322 tons per annum, $5,	1,610.00	
Engineer, Ass't. and Fireman per day, $4.50,	1,642.50	
Oil, Hemp, &c., ...	450.00	
Repairs, ...	750.00	
Insurance, ...	250.00	
Total annual cost,	4,702.50	
The capital for maintenance being . . .		78,375
Expenditure for Steam Power and Pumping,		$126,815

For the steam works and pumping at other localities specified in the estimates the principles will be the same, but the amount will be modified by the situation, lift and other circumstances.

If the head for distribution were diminished twenty feet, the above total expenditure might be reduced to$114,315.

Cost of Supplying New Haven from the Quinnipiac.

The dam is eleven feet high, and one hundred feet wide; made of best masonry, resting on a broad apron of timbers. The water issues through guard gates. The canal is four feet deep, twenty wide on bottom, the bank seven feet on top, and from four to three above water. An ample weir is provided. The wheel and pump house will be erected about two miles and three quarters south of the dam. Two sloping mains will conduct the water from the pumps. The open channel leading to the reservoir is seven and a half feet on bottom, and protected with a fencing so close and strong as to prevent access of persons and animals. The small water courses will be passed above the conduit by channels of masonry.

Estimate.

Dam across Quinnipiac, ...			$4,020.00
Guard Gates and Gearing, ...			796.20
Waste weir in Canal, ...			600.00
Canal $2\frac{8}{10}$ miles, including right of way and fencing,			18,821.50
Expenditure for lifting, viz:			
House, Wheels, Pumps, &c., . .		$18,800	
Capital for 1,000,000 gallons, . .		25,833	44,633.00
Double rising mains, 18 inch diameter,			
1,350 feet, at $8, . . .		$10,800	
Rock excavation for main, . . .		80	
Influent Well for Conduit,		160	
1700 feet Conduit 3×4 half arch, half cut,		2,125	
2100 feet rock, cut for do.	50 cts.	1,050	
3000 feet earth, do.	16 cts.	480	
Well and Gate, ...		160	14,855.00
Open Channel 2,900 feet, . . .		3,370	
Tunnel 200 feet, . . .		1,330	
Fencing 352 feet, at $5, . .		1,760	6,460.00
Amount carried over,			$90,185.70

	Amount brought over,	$90,185.70

Receiving Reservoir.

10,000 cubic yards earth, 15 cts. .	$1,500.00	
2,000 cubic yards puddling, 50 cts. .	1,000.00	
Puddle ditch, ...	300.00	
Grubbing and clearing 2½ acres, .	1,000.00	
240 perch slope wall, $2.50, . .	600.00	
Fencing around reservoir, ...	1,000.00	
		5,400.00
Open channel, 3,000 feet rock and earth,		13,300.00
Conduit, 5000 feet, $2.50, . . .	12,500.00	
Conduit, 12,800 feet, half rock, . .	16,000.00	
Earth, 144,000 cubic yards, 20 cts. .	28,800.00	
Rock, 13,000 cubic yards, 60 cts. . .	7,800.00	
Back filling, 24,000, 6 cts. . . .	1,440.00	
Three Ventilators, ...	300.00	
Culverts, 60 perches, $8. . . .	480.00	
Land and Damages, ...	7,200.00	
		74,520.00
Distributing reservoir, ...		32,620.00
Double 21 inch mains to city laid 15,600 ft. $10 per foot, . . .	156,000	
Crossing Mill River, ...	2,546	
Two Stop Cocks, ...	300	
		158,845.00
Contingencies, ...	13,000	
Engineering, ...	12,000	
		25,000.00
Total for Introducing Water,		$399,870.70

A rapid survey of Muddy brook was made from Tyler's Mill to the receiving reservoir at Bronson's brook. The distance was distributed into open channel two miles, conduit a mile and three quarters, and more than two miles of pipe, making the distance very nearly five miles and three quarters, at an expense

rudely estimated at $114,909.00. This amount appeared so great, compared with the object, that no farther critical attention was given to the idea of making that stream auxiliary to the Quinnipiac.

The expense of introducing the Quinnipiac by the channel above described, being in excess of the amount which was anticipated, it became important to consider whether it might not be moderated by an extension of the canal to a more southern locality. At the time of entering upon this enquiry an accurate survey could not be made in season, but by aid of Mr. Ritner's minute acquaintance with the region, I was able to make an approximate estimate, which developed the fact that between thirty and forty thousand dollars might be saved by changing the plan as follows:—

I would replace the present dam at the Quinnipiac factory by a new one, and conduct the main-stream by Canal to the mouth of Muddy brook; taking in this stream and Horton's brook on the way; crossing the Quinnipiac by an aqueduct of masonry, the Canal would be continued to a site near the north extremity of East Rock, and opposite the Gun Factory. Here the pumping would take place by the power of the stream,—the waste ascending into a reservoir on the ridge, whence it would be distributed into the city.

It is an objection to this plan of supply that fifteen cubic feet per second would probably be lost by leakage and evaporation in the Canal. On the other hand, the two streams above united will supply a large part of the waste, leaving the main stream not seriously impaired in amount and efficacy.

COST OF SUPPLYING NEW HAVEN FROM MILL RIVER.

First, by power of the Stream.

The dam proposed at the Clock Factory would consist of an embankment across the present channel and a weir of masonry continued in the same line on the flat that abuts against the foot of the eastern ridge. Down the gentle and rocky slope of this hill, the waste water would expend itself—strong abutments and walls being erected for protection, one hundred and fifty

acres will probably be flowed by this arrangement, which will give a head of thirty-four feet. The water for supply and power would make its exit through guard-gates into the Canal before mentioned, on its way to the works near Mr. E. Whitney's dwelling. A spacious race walled enters into the arrangements at this place. Other particulars will be manifested by the estimate, as follows:—

Estimate.

Raising Bridge, &c., north of dam, ...		$6,133.00
Dam 27 feet bank, 75 feet weir, ...		6,825.00
Guard Gates, ...		651.20
Canal, 4000 feet, ...		13,973.70
Pump house, Machinery, Race, capital, &c.,		46,590.00
Double 18 inch rising mains, set 2000 feet, $8,		16,000.00
Reservoir on Sachem hill, ...		32,500.00
Double 21 inch mains to Chapel-st., 8,200, $10 per ft.,		82,000.00
Stop Cocks, ...		250.00
Land and damages, not including flowage of,		10,000.00
Contingencies, ...	$8,800.00	
Engineering, ...	10,000.00	
		18,800.00
Total for raising and conducting to Chapel-st.,		$233,722.90

Second, by Steam Power.

A basin of one acre is to be excavated at the locality of the water-works before mentioned. This is to receive through a conduit the flow from the foot of the Gun Factory dam. The arrangements have been before described and the course of the water from the pumps to the reservoir on Sachem's Hill and to the city, will be the same as in the last article.

Basin, 10,000 cubic yards, 16 cts. . . .	$1,600.00
Conduit from river, 600 feet laid, . . .	1,440.00
Influent chamber for do., ...	1,575.00
Wall for Basin, 250 feet, $3, ...	750.00
Amount carried over,	$5,365.00

Amount brought over,	$5,365.00
Pump-well, ...	500.00
Turning Brook, ...	150.00
Land and damage, ...	1,500.00
House Engines, pumps and maintenance, . .	126,815.00
Double 18 inch rising mains, 2,000 feet, $8, .	16,000.00
Reservoir on Sachem's Hill, ...	32,500.00
Double 21 inch mains to Chapel street, 8,200, $10,	82,000.00
Stop-cocks, ...	250.00
Contingencies, ... $5,000	
Engineering, ... 5,000	
	10,000.00
Total, for raising and conducting to Chapel street,	275,080.00

3d. By Steam-power and from above Churchill's Dam.

The chief advantage of this method would be the diminished cost of raising the water coupled with the opportunity of supplying for the present what shall be taken—an opportunity which may be improved by constructing reservoirs upon the head streams of Mill River. Again, it is true that during eight months of the year, if not nine, all that the city would require for years to come would be no subduction from the useful mechanical effect of the stream, being merely what runs to waste over the dams.

Churchill's dam being forty-two feet above mean-tide, there would be a great saving in the expense of lifting; in fact, a yet greater economy would be realized in the respect named from the dam above. The estimate will show this to be one of the most promising methods of supply. It will be requisite, however, to control the entire stream for ultimate purposes, although not to any extent injurious to the factories for a long period to come. This method did not suggest itself to the Engineer until after the close of the field-work, and the estimates for the open channel are based—as in one instance before mentioned—upon a reconnoisance carefully and repeatedly made by the principal Assistant, Mr. Ritner.

Renewing dam, ...		$3,000.00
Open Channel, 3 miles long, 8 feet bottom,		
13,700 cubic yards of earth, at 13½ c.,	$18,495	
5,000 cubic yards of rock, at $1, . .	5,000	
Four road crossings, ...	250	
Land and damages, ...	1,000	
Fencing 6 miles at $5 a rod, . . .	9,600	
		34,345.00
Engine house, pumps, &c., . . .	36,000	
Maintenance of, ($3,752.50,) . . .	62,542	
		98,542.00
Double rising mains, 18 inches, 1,000 feet, at $8,		8,000.00
Right of way for do., ...		100.00
Reservoir and mains into city, . . .		114,250.00
Contingencies and Engineering, ...		5,250.00
		$263,487.00

Supply of Water to the City from Westville.

As the locality in this instance would be at the same distance very closely with that below the Gun Factory from which the water of Mill River would be pumped, it may be assumed at the estimate before given, or $275,080. The reservoir, however, would not have an equal elevation with that on Sachem's Hill, by perhaps ten feet—a circumstance balanced in a measure by the diminished expense of pumping. The supply may, however, be less copious at some distant day than might be fully adequate to the demand.

Distribution.

It is proposed to turn one sixteen inch main along Chapel street, West to Dwight street, and the other along Elm and St. John streets to East street, to cross these mains by four twelve inch branches through East, Olive, Church and Howe streets, and to intersect these in both directions through all the other streets by six inch branches. Four inch branches have been used in the cities, but are coming to be out of favor.

With a head diminished twenty feet, the expense of distribution might be reduced twenty thousand dollars.

6,850 feet of 16 inch pipe at $3.50, . . .	$23,970.00
13,450 feet 12 inch pipe at $2, . . .	26,900.00
127,200 feet 6 inch pipe at $1.10, . . .	139,920.00
180 Hydrants at $60 each, ...	10,800.00
2 eighteen inch Stop Cocks at $200, . . .	400.00
16 twelve inch Stop Cocks at $65, . . .	1,040.00
84 six inch Stop Cocks at $35, . . .	2,940.00
Pipe house and testing apparatus, . . .	4,500.00
Sundries, ...	5,500.00
	$215,970.00

Summary of the foregoing results, exhibiting the entire cost of each method of supply, including distribution:

Cost of Supplying from

Quinnipiac on ridge, $615,840.70, cost of water to be added.
Quinnipiac on plain, say, 580,000.00, cost of water to be added.
Mill river by water power, 449,692.90, cost of water to be added.
Mill river by steam, 491,050.00, water free.
Mill river from Churchill's, 479,457.00, cost of water to be added.
Westville same as Mill river by steam.

It should be observed in the comparison of the foregoing methods and amounts, that they present a fair comparative view for the present time only, when 1,000,000 gallons will meet the ordinary daily demand; if 2,000,000 were requisite instead of one, there would appear against the method by steam, when compared with water power, a balance of about $60,000 more than at present, and the like amount for each additional million.

It should also be observed, that by a moderate addition of force at the turbines of Mill River, the work of both might be continued through nineteen hours, and supply the whole 1,900,000, which that stream is competent to lift at its minimum flow, and at an addition to the capital before stated, of only

$13,000; also that, by working the turbines at the Quinnipiac twenty-four hours to the day, 2,400,000 may be supplied constantly by an expense equivalent to the interest of only $15,000; and that the whole which the Quinnipiac is competent to throw at its minimum, being 2,900,000 gallons, might be supplied by the addition of a third turbine, and a corresponding increase of capital to the amount of $25,000.

The proposed steam arrangements at Mill River being competent to lift 2,400,000 gallons in twenty-four hours, and nearly 4,000,000 in an exigency, the above supply could be realized from that source by an additional yearly expenditure, equivalent to the interest of $63,000.

Alexander C. Twining, *Engineer.*

New Haven, October 5th, 1852.

MEMORANDA

Of waters for analysis and experiment from the streams around New Haven, referred to in Report of Alexander C. Twining, on introducing Water into New Haven.

New five gallon demijohns were procured, well and repeatedly rinsed, first by the druggist, and afterwards by Mr. Twining at the streams. When filled it was by careful immersion to about mid depth of water, every precaution being employed to obtain the water in its natural or normal condition. Immediately after fillage the demijohns were marked by short white cords or strings tied to one of the handles of the wicker work, the cork having been put tight in its place, and never afterwards disturbed. The demijohns were set at once into Mr. Twining's cellar, and soon after spotted with as many black wax seals on the side of the wicker or basket work, as the cords that had been put, and were still left, on the handles. By these spots cords were connected from sides to corks, forming a guarantee, (if undisturbed,) that the corks had remained undisturbed. Subsequently, proper labels with numbers 1, 2, 3, (corresponding to the number by cords and by spots,) were put on the demijohns filled by Mr. Twining, and No. 4 on one filled, in accordance with Mr. Twining's directions, by the principal Assistant, Mr. Ritner, and set with the others in the cellar, and by their side.

Demijohn No. 1; having also one cord on handle, and one black spot of wax, as above, on the side. *Mill river water.*

Filled August 21st, at one P. M., by A. C. Twining, from pond of Whitney's second or upward gun works, it being also the first pond below Waite's mill and dam. Water taken immediately above race in the deep forebay. The day and several preceding days dry.

Demijohn No. 2; having also two cords on handle, and two wax spots, as above, on side. *Water of the Quinnipiac.*

Filled the same, August 21st, at three P. M., by A. C. Twining, from the main channel, under the bridge immediately below the Quinnipiac Factory. Water pouring a thick sheet over the dam, and the factory or mill not in motion.

Demijohn No. 3; having also three white cords tied to handle, and three wax spots, as above, on one side. *Water of the Main Beaver Pond.*

Filled the same, August 21st, at seven P. M., from outlet of Beaver Pond, in deep water, say two hundred feet above, or East of the road and bridge.

Demijohn No. 4; filled September 29th, at three P. M., by Mr. Michael Ritner, principal Assistant, below Jacock's dam, in Westville. Water temperature 66° F., air temperature 64° F. Demijohn was brought to Mr. Twining's, and set in his cellar, by the side of the preceding.

Demijohn not marked; this was filled by Mr. Ritner, September 6th, at eleven A. M., from *Muddy Brook,* one-fourth of a mile above Tyler's mill. Water, 64° F., air 74° F. It was brought and set in cellar by side of the first three preceding.

Also new jars were procured and rinsed, filled, stopped with ground stoppers, marked, and new lead pipe was put in each. The pipe being a trifle soiled, was scoured with dry emery, (or steel grains,) and wiped again and again with paper. Two fragments were put into each jar, one clear pipe, and one with brass tube soldered on. Each jar was wrapped in paper, and all were set together into a dark closet.

First jar; having one white cord or string tied around neck as its mark. *Mill River water,* taken beneath bridge next below Waite's dam, where also the guages had been principally made. Filled, supplied, wrapped and set away by A. C. Twining, August 27th. Filled at 12 hours and 40 minutes, P. M. Water temperature 74° 3 F., air 86° F. Day cloudy and damp, but with occasional sunshine.

Second jar; having two cords around neck as its mark. *Quinnipiac water.* Taken beneath bridge below Quinnipiac Factory, (where also guages were chiefly taken,) the same 27th August, at 4 hours and 30 minutes P. M. Water 74° 3 F., air 79° F., treated by A. C. Twining as the preceding.

Third jar, marked " Beaver Ponds." Taken by Mr. Ritner, principal Assistant, from outlets of Beaver Ponds, September 4th, 1852, 4 P. M. Water 72° F., air 79° F., day clear. Taken to Mr. Twining's house, and treated by Kinsley Twining in the same way as the first two.

Fourth jar unmarked, except by date of its reception at Mr. Twining's. *Muddy Brook water.* Taken by Mr. Ritner at time and place of the above unmarked demijohn—to wit, one-fourth mile above Tyler's mill, September 6th, 11 A. M. Water 64° F., air 74° F. Treated by Kinsley Twining as others.

All the above was done as part and parcel of my survey and examinations, in the summer and fall of 1852.

ALEXANDER C. TWINING, *Engineer.*

To Hon. A. N. Skinner, Chairman, &c.

MR. RITNER'S REPORT.

New Haven, Nov. 16, 1852.

Hon. A. N. Skinner:

Dear Sir,—Below I give you the estimated cost of an open canal from the Quinnipiac Factory Dam, to a point near the South East end of East Rock, crossing the Quinnipiac at Sackett's Point. Length of Canal, 9.43 miles, tail race 600 feet.

380,000 cubic yards earth, at 12 cts.	$45,600
2,500 cubic yards earth, at 50 cts.	1,250
Guard Gates and Waste-weir,	1,396
Sundries,*	1,920
Sundries,*	4,000
Sundries,*	900
Sundries,*	2,800
Quinnipiac Aqueduct,	12,000
Grubbings and Clearings,	1,500
Pine River Feeder,	2,000
Right of Way and Fencings,	18,000
Engineering, &c.,	2,500
Total, Canal,	$93,866

The distance from the Pumps to the Distributing Reservoir would be 900 feet, and from thence into the City of New Haven to State and Elm streets, 9,500 feet.

The cost of the Distributing Reservoir of 1¼ acres area, would not exceed $13,000.

I estimate the cost of 9,500 of main from the reservoir on the South end of East Rock, to the corner of State and Elm streets, at $5 per foot, making	$47,500
Crossing Mill River with stone arch, and raising highway 15 feet,	6,850
	$54,350

* Items omitted for reasons before mentioned.

The pipe estimated is 21 inches, and would deliver (at the corner of State and Elm) something more than 100,000 gallons per hour, 30 feet below the surface of the water in the reservoir.

Yours respectfully,

M. Ritner.

Summary by Committee of Mr. Ritner's Estimate of Quinnipiac, by Cedar Hill.

Cost of water near Cedar Hill, ...	$93,866
Reservoir, ...	13,000
Distributing main, 9,500 feet, to corner of State and Elm streets,	47,500
Crossing Mill River, with stone arch, and raising highway 15 feet,	6 850
	161,216
Double Rising Mains, 900 feet, $8 per foot, ...	7,200
Mr. Twining's Estimate of Wheel-house, wheels, apparatus, &c.,	18,800
	187,216
Committee's Estimate of Engineering, Damages, Contingencies, &c.,	11,350
Cost at Corner of State and Elm streets, ...	$198,566

Quinnipiac by Whitneyville.

If the open Canal were made to terminate at a point 6,000 feet North, making the length about 8¼ miles, with the view of passing the water to a Distributing Reservoir on Sachem's Hill, the cost would be estimated thus:

Open Canal, ...	$86,000
800 feet double Rising Mains, at $8, ...	6,400
2,000 feet Conduit, to a point East of, and overlooking Gun Factory, at $2.50, ...	5,000
3,500 feet Pipe across valleys of Mill River, .	14,000
Crossing of Mill River, ...	3,000
4,400 feet Conduit on Sachem's Hill, to a point at South end of Mrs. Hillhouse's orchard, . . .	11,000
Sundries, ...	2,000
Total,	127,400

1. The Committee in their estimate placed the Reservoir still further North, thereby diminishing the iron mains to 2,200 feet, and increasing the Conduit to 5,900 feet; also estimated single instead of double rising mains.

Summary by Committee of Mr. Ritner's Estimate of Quinnipiac by Whitneyville.

Total above,	$127,400
Mr. Twining's estimate for Reservoir,	32,500
Mr. Twining's estimate for Wheel-house, Pumps, &c.	18,800
	$178,700
Distributing main, (20 inches,) 4,225 feet, at $5 per foot,	21,125
Reservoir, Engineering, Contingencies, &c., estimated by Committee,	15,825
	$215,650

The cost of an open Canal from the Clock Factory on Mill River to Whitneyville, following the East side of the valley, distance 2,500 feet, I estimate at

26,000 cubic yards of Earth, at 12½ cents,	$3,250
2,000 cubic yards of Rock, at 50 cents,	1,000
Guard Gates and Turnpike Bridge,	1,250
200 cubic yards Masonry, at $5,	1,000
Total,	$6,500

The above estimate does not include the cost of the Dam and road crossing at the Clock Factory; the cost of these, together with that of the Waste-weir, will be found in Mr. Twining's Report.

The length of rising main from the point where the Canal terminates to a point on Sachem's Hill, having an elevation of 130 feet above mean-tide, would be 3,300 feet, and the length of Conduit from this point to the South side of Mrs. Hillhouse's orchard, would be the same as before estimated for the waters of the Quinnipiac, 4,400 feet, making the cost—

Open Cannal,	$6,500
3,300 feet double Rising Mains, at $8,	26,400
4,400 feet Conduit, at $2.50,	11,000
Crossing Mill River,	3,000
Right of Way and Fencing,	3,500
Engineering, &c.,	1,500
Total,	$51,900

The cost of the Pumps is not included in the above estimate.

Yours Respectfully,

M. Ritner.

Summary by Committee of Mr. Ritner's Estimate of Mill River by Water Power.

Total as above,	$51,900.00
Cost of water without Canal, ...	69,609.20
Mr. Twining's Estimate for Reservoir, ...	32,500.00
Mr. Twining's Estimate for wheel-house, wheels, pumps, &c., . .	18,800.00
Distributing Main, 4,225 feet, at $5, ...	21,125.00
Distributing Reservoir, Damages, Engineering, Contingencies, &c., Estimated by Committee, ...	12,715.80
	$206,650.00
Deduct Sundries twice estimated above, ...	5,000.00
	$201,650.00

MR. RITNER'S REPORT

IN REGARD TO THE WATERS ANALYZED BY PROFESSOR PORTER.

New Haven, October 29th, 1852.

Hon. A. N. Skinner:

Dear Sir—Below I give you the information you desire, relative to the water obtained by me for analysis.

Demijohn marked A. No. 1.—From Pine river, one mile from its mouth, October 25th, 1852, half-past ten o'clock, A. M., temperature of the air, 64°; of the water, 50°.

Demijohn marked A. No. 2.—From Quinnipiac, below Factory dam, October 25th, twelve o'clock, M., temperature of the air, 67°; of the water, 53°.

Demijohn marked A. No. 3.—From West River, below the junction of all the streams, October 29th, ten o'clock, A. M., temperature of the air, 62°; of the water, 51°.

Demijohn marked A. No. 4.—From Mill River at Clock Factory, October 29th, half-past eleven o'clock, A. M., temperature of the air, 64°; of the water, 50°.

Demijohn marked A. No. 5.—From Mill River below Gun Factory, October 29th, twelve o'clock, M., temperature of the air, 64°; of the water, 50°.

Yours respectfully, M. Ritner.

Note by Committee.—The waters collected by Mr. Twining, were sent to the Laboratory for experiments. But as they had been standing a long time, Professor Porter preferred to make his principal examination and analysis on waters more recently taken from the streams. The analysis here reported was made upon those above described by Mr. Ritner.

PROFESSOR PORTER'S REPORTS.

New Haven, Nov. 18, 1852.

Hon. Aaron N. Skinner :

Dear Sir,—I give below the result of the analysis of the waters, which you left with me for examination.

The principal difference perceptible to the eye in the several specimens, consists in the presence of a small quantity of flocky organic matter, suspended in No. 3, which is not observable in the others.

The organic or vegetable matter present in the different waters, varies from one part in 97,000, to one in 28,000, No. 2 containing the smallest quantity, and No. 3 the largest. As respects the presence of organic matter, No. 2 is therefore preferable to any of the other waters examined. The average quantity in the five specimens, is about nine-tenths of that found in the Schuylkill water, one-fourth of that in the Croton, and nearly twice that in the Cochituate. No. 2 contains the same quantity as the Cochituate, one-half as much as the Schuylkill, and one-seventh as much as the Croton.

With respect to the relation of the quantity of organic matter present in a water to its action on lead, different opinions are entertained. By some chemists it has been supposed to exert a protecting effect due to the tendency it possesses, to appropriate to itself the oxygen dissolved in the water, and again by its decomposing effect upon nitrates, which increase the action of water upon lead. This is the opinion expressed in the Report of the Water Commissioners of the city of Boston, with reference to the use of lead pipe, in conducting water in that city. On the other hand, Graham, Miller and Hoffman, English chemists of high reputation, assert that the presence of organic matter increases materially the action of water on lead. This opinion is the result of the most recent investigation that has been made on the subject and is probably correct. As far, therefore, as the action of water on lead

depends upon the organic matter which it contains, it would be less in the case of most of these waters, than in the case of Croton or Schuylkill water, and as little as in the case of Cochituate. It would, further, be less in the case of No. 2 than in either of the other New Haven waters.

The quantity of *inorganic* or mineral matter present in the different specimens does not differ very materially, the variation being between one part in 13,000, and one in 17,000, and the average being about one in 15,000. This is about one-half of the quantity found in the Croton water, nine-tenths of that in the Schuylkill, and three times that in the Cochituate. The data for the comparison with these three waters, are found in an article by Professor B. Silliman, Jun., in the Journal of Science for 1846.

The composition of the mineral matter present in the different specimens is also very similar, consisting in each of Carbonic and Sulphuric Acids, Silica and Chlorine, combined with the following bases, viz: Potassa, Soda, Lime, Magnesia, Alumina, and Oxide of Iron. Carbonates of Lime and Magnesia, (Limestone,) Sulphate of Lime, (Gypsum,) Chloride of Sodium, (common Salt,) and Silicates of Alumina and Potassa, such as result from the decomposition of Feldspathic rocks, are the principal constituents. Nos. 3 and 4 contain, as far as can be judged from qualitative experiments, more Iron than the other two, and No. 3 more Alumina, but this difference is of no practical importance. None of the substances mentioned are in the least degree deleterious to health. The difference between No. 2 and Nos. 4 and 5, in respect to inorganic matter, is not at all material, and No. 2 is, therefore, to be preferred to any of the others on account of its smaller quantity of organic matter.

Nos. 2, 4 and 5, are all purer than either Schuylkill or Croton water. All contain a larger portion of inorganic matter than Cochituate, and all, excepting No. 2, a larger portion of organic matter.*

It is to be borne in mind that the purity of water is no security against its action upon lead. On the contrary, rain water,

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* Note by Committee.—No. 1, Pine River. No. 2, Quinnipiac. No. 3, West River. No. 4, Mill River, at Clock Factory. No. 5, Mill River, below Gun Factory.

or distilled water, which comes nearest to being absolutely pure, acts more readily on this metal than either spring, lake or river water, which always contain more or less mineral matter in solution. Carbonate of Lime is said to exert the most decided protecting influence. This substance is present in the New Haven waters in small quantity. The precise amount has not been determined. Carbonates of Potassa and Soda, again, increase the action of water on lead. Neither of these are present in the waters examined. Nitrates have the same effect, but there is no reason to apprehend increased action from this source in the case of river waters. Contrary to the commonly received opinion, Graham and Hoffman have concluded as a result of recent experiment, that Chlorides also increase the action of water upon lead. Chlorides are present in the New Haven waters, but the quantity has not been determined.

The connection with brass cocks increases the action of water on lead pipe. Connection with the iron mains is said to have the same effect, but difference of opinion exists on the latter points.

Accompanying this, on a separate sheet, you will find the more precise results of the analyses in a tabular form.

I am, Sir, with the highest respect,

Your most obed't servant,

JOHN A. PORTER.

P. S. Since writing the above, I have examined the four specimens of water in which lead pipe has been immersed, and find no trace of lead in either, excepting the one marked "Water that came September 7th." This contains the *merest trace*. The incrustation on the surface of the pipes might, however, be removed by running water, and the water thus become contaminated. There is a sediment on the bottom of two of the jars which probably contains lead, and would have the same effect. In accordance with your request, I have left the sediment undisturbed, for a subsequent examination. J. A. P.

NOTE.—The sediment referred to in the Postscript, was subsequently examined. In the jar marked *Beaver Pond, Sept. 4th*, 1852, it was accumulated in considerable quantity; in the one marked *water that came Sept. 7th*, there was very little. The sediment from each yielded lead before the blowpipe.

Result of Professor Porter's Analysis, in a Tabular Form.

The amount of solid matter contained in a pound avoirdupois, of each of the waters, is given in Table I, in French Grammes, as it was actually weighed. Table II gives the number of *grains* of solid matter in a gallon of each of the New Haven waters, and of Cochituate, Schuylkill and Croton water, and is deduced by calculation from Table I and other sources. Table III gives the number of parts by weight of solid matter in one million parts by weight of the several waters.

TABLE I.

Solid matter in a pound, expressed in Grammes.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Organic,	.0078	.0045	.0151	.0064	.0059
Inorganic,	.0332	.0282	.0295	.0250	.0260
Total,	.0410	.0327	.0446	.0314	.0319

TABLE II.

Grains of Solid Matter in a Gallon.

	1.	2.	3.	4.	5.	Croton.	Schuylkill.	Cochit.
Organic,	1.	.6	1.9	.8	.7	4.3	1.2	.6
Inorganic,	4.3	3.6	3.7	3.2	3.3	6.6	4.3	1.2
Total,	5.3	4.2	5.6	4.0	4.0	10.9	5.5	1.8

TABLE III.

Parts of Organic and Inorganic Matter by weight, in a million parts water by weight.

	New Haven.*					Croton.	Schuylkill.	Cochituate.
	1.	2.	3.	4.	5.			
Organic,	18	10	35	15	13	72	20	10
Inorganic,	77	65	68	58	59	115	74	21
Total,	95	75	103	73	72	187	94	31

* Note by Committee.—No. 1 was taken from Pine River. No. 2 from the Quinnipiac. No. 3 from West River. No. 4 from Mill River, at the Clock Factory. No. 5 from Mill River, below the dam at the Gun Factory.

Prof. Porter's Examination of Well Waters of New Haven.

The quantity of organic matter is smaller than in the river waters. The precise amount was not determined. The amount of inorganic or mineral matter, is given in the following tables, and is much larger than in the river waters.

Amount of Inorganic matter in one pint of the several waters, expressed in French Grammes.

No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
0.1184	0.1716	0.3092	0.0722	0.1186

No. grains in a Gallon calculated from the above.

No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
15.2	22.1	39.8	9.3	15.2

No. parts by weight in a million parts water by weight.

No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
270	394	709	166	270

The composition of the mineral portion differs from that obtained from the river waters, in its larger relative proportion of Silica, and in the presence of small quantities of Phosphoric and Nitric Acids—or more properly, compounds of these acids. The presence of the latter substances is no objection to the waters.*

As a matter of curiosity, or of scientific interest rather than of practical importance, I append the results of a microscopical examination of the river and well waters, for which I am indebted to Mr. Ogden Rood, of the Analytical Laboratory. I am also indebted to Mr. William I. Craw, of the Analytical Laboratory, for assistance in the above analyses and in those previously reported.

Note by Committee.—Below is the account of the wells in the city, from which the waters were taken by Wadsworth Terry, Assistant in the Water Survey.

No. 1, Pump on South-East corner Green, 51° Temperature.

No. 2, Bath-house, Orange street, 56° do.

No. 3, Pump at corner of Fleet and George streets, 53° do.

No. 4, Pump corner State and Olive streets, 52° do.

No. 5, Pump in Chapel, above Park street, 51° do.

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* The presence of Nitrates would tend to increase their action on lead. Whether they are in sufficient quantity to make a perceptible difference in this respect, can only be determined by experiment.